13:56:39 OCA PAD AMENDMENT - PROJECT HEADER INFORMATION 11/08/9

Activ

Project #: B-03-619 Cost share #: Rev #: 5
Center # : 10/24-6-R8732-0A0 Center shr #: OCA file #:
Work type : RES
Contract#: 9510027 Mod #: 2 Document : SUBCON
Prime #: DAMD17-95-2-5020 Contract entity: G

Subprojects ? : Y CFDA: NA
Main project #: PE #: NA

Project unit: BEC Unit code: 03.010.203
Project director(s):
TOLER J C BEC (404)894-3964

Sponsor/division names: MEDICAL COLLEGE OF GA / AUGUSTA, GA
Sponsor/division codes: 400 / 018

Award period: 950630 to 961031 (performance) 961130 (reports)

Sponsor amount	New this change	Total to date
Contract value	22,015.00	536,391.00
Funded	22,015.00	536,391.00
Cost sharing amount		0.00

Does subcontracting plan apply ?: N

Title: A DUAL-USE TELECOMMUNICATIONS SYSTEM FOR DELIVERING MEDICAL CARE

PROJECT ADMINISTRATION DATA

OCA contact: Ina R. Lashley 894-4820

Dir of telemedicine Ctr.

Sponsor technical contact
(Max Stachura)
DR. ~~JAY SANDERS~~
(706)721-6616

MEDICAL COLLEGE OF GEORGIA
TELEMEDICINE CENTER
1120 15TH STREET
AUGUSTA, GA 30912

Sponsor issuing office

CAROLINE W. WITT/DR J. R. CLAYBROOK
(706)721-2592

MEDICAL COLLEGE OF GEORGIA
OFFICE OF GRANTS & CONTRACTS
1120 15TH STREET
AUGUSTA, GA 30912-4810

Security class (U,C,S,TS) : U ONR resident rep. is ACO (Y/N): N
Defense priority rating : NA NA supplemental sheet
Equipment title vests with: Sponsor GIT X
NONE PROPOSED. (SEE SECTION 11 FOR DETAILS).
Administrative comments -
MOD #2 ADDS $22,015 AND MODIFIES STATEMENT OF WORK, WITHOUT EXTENSION.

CA8120 Georgia Institute of Technology Page: 1
Office of Contract Administration 20-NOV-1997 10:14
PROJECT CLOSEOUT - NOTICE

Closeout Notice Date 20-NOV-1997

Project Number B-03-619 Doch Id 40358

Center Number 10/24-6-R8732-0A0

Project Director TOLER, JAMES

Project Unit BEC

Sponsor MEDICAL COLLEGE OF GA/AUGUSTA, GA

Division Id 5785

Contract Number 9510027 Contract Entity GTRC

Prime Contract Number DAMD17-95-2-5020

Title A DUAL-USE TELECOMMUNICATIONS SYSTEM FOR DELIVERING MEDICAL CARE

Effective Completion Date 31-OCT-1996 (Performance) 30-NOV-1996 (Reports)

Closeout Action:	Y/N	Date Submitted
Final Invoice or Copy of Final Invoice	Y	05-MAR-1997
Final Report of Inventions and/or Subcontracts	Y	
Government Property Inventory and Related Certificate	Y	
Classified Material Certificate	N	
Release and Assignment	Y	20-MAR-1997
Other	N	

Comments

Distribution Required:	
Project Director/Principal Investigator	Y
Research Administrative Network	Y
Accounting	Y
Research Security Department	N
Reports Coordinator	Y
Research Property Team	Y
Supply Services Department/Procurement	Y
Georgia Tech Research Corporation	Y
Project File	Y

NOTE: Final Patent Questionnaire sent to PDPI

B-03-619
#1

Project No. B03-619

A DUAL USE TELECOMMUNICATIONS SYSTEM FOR DELIVERING MEDICAL CARE (SOUTHEAST REGION TELEMEDICINE TESTBED)

FINAL REPORT

Submitted To:

MEDICAL COLLEGE OF GEORGIA
Telemedicine Center
1120 15th Street
Augusta, GA 30912-1655

Prepared By:
James C. Toler, PI
Michael Burrow, John Peifer, Andrew Hopper, Barry Sudduth, and Samir Panchal
BIOMEDICAL INTERACTIVE TECHNOLOGY CENTER
Parker H. Petit Institute for Bioengineering and Bioscience
Georgia Institute of Technology
250 14th Street, N.W.
Atlanta, GA 30332-0200

Contracting through:

GEORGIA TECH RESEARCH CORPORATION
Georgia Institute of Technology
Atlanta, GA 30332

Background

The technical goal of Task 2 was to develop a stand-alone telemedicine system and associated network for monitoring the health of home-bound patients via telecommunications links. The system had to allow patients to communicate audiovisually with a medical care provider as well as perform unassisted diagnostic measurements. Many telemedicine projects are currently underway which link tertiary care facilities with primary care physicians in remote, usually rural, locations. The Electronic House Call (EHC) system represents an extension of that model placing the point of care in the patient's home. It is hoped that this method of managing health care will allow for more widespread access to quality care, reduce the need for emergency care through preventative medicine, and allow patients to return home sooner after being hospitalized.

The requirement to monitor patients at home presented many technical challenges. The first and foremost challenge was to develop a flexible system capable of being used by individuals with varying educational levels, age, economic status, etc. This placed severe constraints on the user interface in particular and on the overall sophistication of the system in general. These limitations related to how the patient will interact with medical instrumentation and the system as a whole. Another challenge was to develop a system capable of reaching the greatest number of patients in their homes. Such a requirement called for a system capable of operating over various telecommunications media such as POTS, CATV, and ISDN in a wired or wireless mode. The EHC system uses both CATV, provided by Jones Intercable serving the Augusta, Georgia area, and ISDN, provided by BellSouth, to link patient homes with care providers at the Medical College of Georgia (MCG) and the Eisenhower Army Medical Center (EAMC).

The technical subcommittee formulated an approach for meeting these challenges early in the project. This approach consisted of the following tasks.

- Define system requirements for monitoring patients at home
- Perform an extensive survey of commercial telemedicine/teleconferencing systems and diagnostic devices to identify existing technology that can meet the needs of the project
- Formulate and implement a network plan to link patients with medical care providers
- Modify an existing system or develop a telemedicine system for home monitoring
- Install systems in the homes of 12 patients and a nursing home and evaluate performance
- Modify the system based on feedback from evaluations
- Install modified system in the homes of 13 additional patients

The following paragraphs will discuss in detail efforts on each of these tasks.

System Requirements

The technical subcommittee met with consortium members at the outset of the project to define functional requirements of a system that would monitor patient vital signs in their homes. These requirements were addressed on a system level and specific physiological parameters to be measured were ignored. The goal was to establish a list of requirements by which commercial teleconferencing/telemedicine systems could be evaluated for meeting the needs of this project and to guide subsequent modification/development efforts.

The first requirement was that the patient must be capable of audiovisual communication with the care provider. A desirable feature of the system was to achieve full motion (30 frames/ second) video while maintaining good audio quality. It was agreed that some motion quality could be sacrificed, possibly as low as 15 frames/second, but that good audio quality must be maintained. This requirement necessitated investigating high bandwidth communication links; however, such pathways do not currently exist among the general population. In the initial review of commercial systems, the ideal performance requirement of low bandwidth with high video frame rates and good quality audio was sought after. Subsequent investigations revealed that a high bandwidth link can be obtained into a large number of homes via CATV and RF Modems allowing the low-bandwidth constraint to be relaxed.

A second requirement was that the system conform to industry standards such that communication links may be established with equipment from many vendors. As telemedicine systems become more widespread, the ability to communicate across vendor boundaries will become critical. Many vendors of teleconferencing equipment support both a proprietary and a standards-based mode. Typically, a proprietary mode offers greater performance due to the fact that technology quickly surpasses standards. All of the telemedicine systems we reviewed specifically for home applications operate in a proprietary mode. This requires that the same equipment exist at all locations.

The third requirement centered around a patient database at a Central Monitoring Station (CMS). The CMS system must be capable of storing patient information, allowing recall of that information, and providing trend data. The ability for patients using the EHC system to perform vital signs measurements on a routine schedule prescribed by a medical care provider was key to the project. This information is captured locally and transferred to a CMS where trends and statistics regarding the patient are kept. A desirable feature of the system was that this data capture and transfer be performed automatically without intervention from a medical care provider. Many research programs have been funded and are currently underway to develop a comprehensive electronic patient record. It was not our intent to parallel the efforts of others by developing a comprehensive patient record, but to provide some rudimentary tools for capturing patient information from measurements made at home using the EHC system. A comprehensive electronic patient record will be an integral component of the EHC system in the future and subsequent database development will be performed in collaboration with entities currently being funded to address this need.

A fourth requirement was that the system must be capable of performing diagnostic measurements, recording that information, and transferring it to the CMS. In reviewing commercial telemedicine systems, very few were found that support the measurement of more than two physiological parameters. Typically, these systems supported blood pressure measurement and heart and lung sounds. Even fewer commercial systems were capable of automatically collecting that information and transferring it to a CMS. Initial investigations were not concerned with which parameters were required for monitoring patients under this project, but focused on determining capabilities of commercial systems. At a later date, clinicians identified patient populations that would be monitored under this project and an associated set of physiological parameters to be monitored. The parameters were prioritized based on clinical needs and ease of interface with a computer-based telemedicine system. The first six parameters, which were subsequently incorporated into the system, were

- Blood Pressure and Heart Rate,
- Heart and Lung Sounds (Electronic Stethoscope),
- Pulse Oximetry,
- Temperature,
- Electrocardiogram,
- and Weight.

A second set of parameters were identified which will be included in Phase II enhancements of the system. These are

- Spirometry,
- Blood Chemistry,
- and Doppler Ultrasound.

The fifth requirement involved home-bound patient education. It was determined that the system should be capable of allowing patients to access medical information. Ideally, this would be patient specific information; however, access to general information on illnesses, injuries, treatment, medication, etc. was targeted initially. This has been accomplished in the current EHC system by incorporating a commercial CD-ROM designed for home health care - AMA Family Medical Guide. Since the telecommunications link into the home accommodates data as well as audio and video, patient specific information (text and/or video clips) could be downloaded to a telemedicine system for later review by the patient. As will be discussed later, the network configuration and communications protocols chosen for this project allow access to medical information through the Information Superhighway; however, this capability has not been implemented in the current EHC system. Information available on the World Wide Web (WWW), while in many cases not user friendly, can provide patients with medical resources and support group services not previously available. Phase II developments will take advantage of the WWW by establishing customized interactive Web pages that patients can access.

A sixth requirement was the ability to capture an image and to control the camera at the remote site. The ability to capture an image, transfer it to the CMS, and store it in a patient record for subsequent recall allows physicians to objectively evaluate a patient's progress. The ability to perform this function requires that a data path be established between the CMS and the patient site. Another advantage gained by taking a still image is that the image can be displayed at the CMS with greater resolution than the live image. This is due to the fact that the image is captured at the patient site before undergoing compression which generally degrades the image. Remote camera control is a feature that few commercial system offer. It was agreed that a desirable feature of the system was to allow the care provider at the CMS to control the camera (pan, tilt, zoom) at the patient site.

The seventh requirement identified is a simple, graphical user interface. The method in which the patients interact with the system had to be intuitive. Patients using this system can range in age from small children to the elderly. In reviewing commercial systems, much emphasis was placed on how the patient would actually control the system. It was felt that a patient could not be required to use a mouse or keyboard to interact with the system. The final system configuration incorporates a touch screen monitor allowing patient to interact with the system via touch. In addition, the diagnostic instrumentation chosen for this application had to be manageable by an unattended patient.

The eighth and final requirement involved multi-point conferencing for the purpose of developing support groups for patients with common illnesses. In this scenario, patients could not only place an audiovisual call to their care provider, but could also call anyone else to whom they had authorization to connect. It was agreed that while this feature was highly desirable, it was not essential for the initial project. Recent developments by Intel in their ProShare videoconferencing system allows for multi-point connectivity. The requirement of allowing patients the ability to form "support groups" through multi-point conferencing will be address in Phase II.

These eight requirements were used in evaluating commercial products for use in the EHC project. As will be shown later, the consortium agreed to develop a custom telemedicine system as no suitable commercial system could be found that would be available in the time-frame of this project. The above requirements have been used as a guide in developing the EHC telemedicine system.

Systems Survey

Telemedicine/Videoconferencing Systems

An extensive survey of commercial telemedicine/videoconferencing systems was conducted in collaboration with representatives from the Medical College of Georgia (MCG) and Eisenhower Army Medical Center (EAMC). The initial focus was on telemedicine systems currently being used to monitor individuals in their homes. Three systems were evaluated through demonstrations and/or presentations at MCG and at EAMC - Health Tech Services, Corp. (HANC), H.E.L.P. Innovations, LC (Resource Link) and American Telecare, Inc. (PTS100S). Subsequently, five teleconferencing systems were evaluated to determine if the audiovisual capabilities could be integrated into a telemedicine system - VTEL, Inc. (DeskMax), Data Point, Inc. (MINX 2000), AT&T (Picasso), MD/TV (Housecall), and British Telecom (VC7000 and VC8000). Since these teleconferencing systems were not designed for telemedicine applications, many of the requirements listed above were not met. It was determined that if one of these systems were deemed appropriate for the EHC project, it would have to be modified substantially. Therefore, initial emphasis was placed on a thorough evaluation of the three systems designed specifically for telemedicine. The results of these investigations are provided in Appendix A entitled "Technical Review of Home Health Telemedicine Systems."

As expected, none of the telemedicine systems evaluated provided the full range of capabilities needed for the Electronic House Calls Project. The Resource Link system allowed for high bandwidth audio and video, but did not provide a data path for transmitting diagnostic information to the CMS. This is the only other tele-home care system utilizing CATV as its communications medium. The PTS100S system by American Telecare used analog phone lines (POTS) and therefore the video quality was poor. An MCI picture-phone, with a miniature screen, was used in this system. A larger 11" screen has been developed and integrated into the picture-phone; however, the image is still poor. The PTS100S was capable of monitoring blood pressure and heart sounds but required two analog phone lines - one for the picture-phone and one for the electronic stethoscope. In addition, a long lead time was required to transfer information from the patient site to the CMS.

The HANC system came the closest to meeting our requirements for the project. This computer-based system was capable of monitoring blood pressure, heart and lung sounds, EKG, and temperature. It utilized analog phone lines to transfer audio, video and data between the patient site and the CMS. Consequently, the video was extremely slow (approximately 3-5 frames/second) and the time required to transfer a "snap-shot" image was long. Although the system did not meet all of our requirements, it was felt that Health Tech, Inc. offered a platform from which to build a system for this project. Health Tech representatives indicated that HANC systems would be available for this project if a suitable collaborative working arrangement could be reached.

The technical subcommittee provided a recommendation, as reflected in the document in Appendix A, based on results of the evaluation of commercial telemedicine systems and the fact that CATV was to be the telecommunications link. In summary, the recommendation was to develop a collaborative relationship with Health Tech (computer-based home-bound patient monitoring system) and H.E.L.P. Innovations (CATV audiovisual telemedicine system) to merge technologies in the development of a telemedicine system utilizing CATV with good quality audio and video, monitoring and recording vital signs as identified above, and transferring that information to a CMS. Subsequent efforts in pursuing this arrangement revealed that Health Tech would not be in a position to begin manufacturing the HANC system until March, 1996. No firm commitment was given regarding delivery of 25 systems needed for this project. It was later learned that the HANC system would not be manufactured until the Fall of 1996. It is still not know if this system is available commercially. In addition, the Resource Link system used CATV in a manner which did not allow transfer of digital data and plans to achieve this functionality were deemed inadequate. As a result, the technical subcommittee began investigating the possibility of developing a custom telemedicine system which could be prototyped rapidly for deployment into patient homes.

The potential of utilizing CATV in conjunction with RF modems (see next section for a detailed description) providing digital access at bandwidths never before achieved into the home steered the investigation toward videoconferencing systems which support a LAN TCP/IP and/or UDP environment. As a result, research staff focused on two videoconferencing systems for integration into a custom telemedicine system - Virtual Desk (ImageLink, Inc.) and Proshare (Intel, Inc.). Both of these system support ISDN and an Ethernet LAN environment. A meeting was scheduled in which representatives from the clinical subcommittee reviewed the two systems and a final decision was made to utilize the Intel Proshare videoconferencing system in developing a telemedicine system for the EHC project.

Medical Diagnostic Devices

Clinical investigators on the project provided a list of six physiological parameters that must be monitored during Phase I of the project. These included Blood Pressure and Heart Rate, Heart and Lung Sounds (Electronic Stethoscope), Pulse Oximetry, Temperature, Electrocardiogram, and Weight. The technical subcommittee began investigating medical devices which will monitor these physiological parameters and that will also interface with a computer-based telemedicine system.

Two approaches were investigated - a component level approach which utilized low-cost medical devices developed for home monitoring and a system approach which consisted of hospital-grade equipment capable of monitoring multiple parameters in one unit.

Several medical devices were obtained and evaluated under each category as listed below.

Component Level Approach
- LifeWatch - Ralin Medical
- Onyx - Nonin
- Palco/8500 - Nonin
- Dynapulse
- ThermoScan
- Electronic Stethoscope - Andrias Tek
- Stethocom II - MTI
- TelePhonic Stethoscope - American Telecare

System Level Approach
- Dynamap - Johnson & Johnson
- Eagle 3000 - Marquette
- Criticare

From a technical perspective, each device was evaluated with regard to how easily it could be integrated into a computer-based system and how much control over the device could be achieved. As envisioned, the patient would activate the monitoring device by selecting options on a computer screen. This required that each medical device have a method of communicating with the computer such that the computer can initiate a measurement. In addition, a data path from the medical device to the computer was required to allow for parameters to be accessed and recorded. While automatic initiation of a measurement as well as transferring and storing the data was a highly desirable feature, it was determined that some parameters could be measured without a link to the computer. For example, temperature and weight could be measured and the resultant value entered via a large on-screen keypad or simply held up to the camera for the care provider at the CMS to record. The final system configuration relies on this method of measurement for the patient's weight only.

Clinicians also identified three additional parameters, as listed in the previous section, which were desirable but not essential in Phase I. Researchers obtained information on several spirometers and one blood chemistry analyzer which were felt to be candidates for the EHC project. One of the spirometers is equipped with a serial port for interfacing with a computer. As a result, this device could be added to the system in the future without much difficulty. The I-STAT system, used for analyzing blood chemistry, was evaluated and found to be relatively difficult to use. It requires the patient to collect a small sample of blood to be deposited into a cartridge. Questions arose as to whether patients could be expected to perform this procedure unattended at home. Nevertheless, the I-STAT system was the most user friendly blood chemistry analyzer commercially available. A serial port connects to a wireless transmitter for sending data to a central computer. With some modifications, it is believed that this device could be incorporated into the system during Phase II.

A project review meeting was held on November 29, 1995 in which clinical representatives were provided an opportunity to evaluate all of the medical devices obtained by the technical subcommittee as well as to review the videoconferencing capabilities being considered for inclusion in the EHC telemedicine system. Following the demonstration, the committee finalized the configuration of the telemedicine system that was to be constructed for the EHC project. The consortium decided to integrate the Intel ProShare videoconferencing system into the EHC product and to pursue the system approach to monitoring physiological parameters. A copy of the slides presented at this meeting is provided in Appendix B. The last slide summarizes the system configuration as agreed upon at this meeting. A more detailed description of the system is provided in the section entitled system development.

Network

Design and Implementation

One of the most challenging technical aspects of this project was defining and implementing a network capable of connecting patient homes with the Medical College of Georgia and Eisenhower Army Medical Center. The network had to be capable of handling audio, video and data with a quality that is acceptable from a medical diagnostic perspective as well as being widely distributed to reach a large population. As the investigation of network possibilities progressed, it became clear that ISDN into patient homes was an expensive route and many areas were not served by ISDN. CATV presented an attractive solution in that it could be used to reach a larger population; however, the technology for setting up a data network over CATV is relatively new.

The potential benefits obtained by establishing a wide area ethernet network running TCP/IP and UDP over CATV became evident as researchers became more familiar with this technology. RF modems can be used to establish a "10Mbps" Ethernet link into the home over CATV. This bi-directional, wide bandwidth, data path into the home has not been possible at a reasonable cost until recently. In addition to providing a large bandwidth link into the home for video, audio, and data, the fact that ethernet is being used allows patients to access the Internet from home given that one of the nodes (MCG, Jones Intercable, or EAMC) has a link to the Internet. This opens possibilities for patient education and medical services to be provided through WWW pages.

The first objective was to test the network concept by establishing a test site. Jones Intercable configured CATV lines between Dr. John Searle's home and his laboratory at MCG to accommodate ethernet using Digital Equipment Corporation (DEC) RF modems. A spectrum analyzer was used to determine the "quietest" frequencies for transmission and reverse amplifies were installed along the CATV run servicing Dr. Searle's home and MCG. The node at MCG was configured as a link into the MCG campus and to the Internet. A test was conducted in late October in which Dr. Searle connected a computer at his home to a server at MCG using the RF modems and CATV lines. Subsequently, he was able to access the Internet and browse WWW sites. This test was successful; however, over the next week it was determined that the link was unreliable. Subsequent attempts to connect using the DEC RF modems failed on a regular basis. An investigation into the cause of this instability ensued.

Much of the equipment utilized in enabling a bidirectional data path over CATV was replaced in tracking down the line instability. Ultimately, the Digital Equipment RF Modems were replaced with Zenith Home Works Universal RF modems (LANHWU-4M) providing a reduced theoretical bandwidth of 4Mbps. Problems with line instability reduced significantly when the modems were replaced. The reduced bandwidth was not a factor in Phase I of the project because Intel ProShare limits the bandwidth of their videoconferencing system to either 200Kbps or

400Kbps and a private network is being used in which only two patients were allowed to connect at any time. Additional tests were conducted between Dr. Searle's home and his laboratory in which timed file transfers were performed to determine a practical throughput over the CATV ethernet. The effective throughput was determined to be approximately 800Kbps which is consistent with transfer rates observed on internal ethernet networks at MCG and Georgia Tech.

A test in which two video conferencing systems were linked over the CATV Ethernet network was conducted in late November. Intel ProShare systems were installed in Dr. Searle's home and his laboratory at MCG. A videoconferencing test was performed over the CATV link with satisfactory results. There appeared to be no difference in video and audio quality as compared with tests performed in a laboratory at Georgia Tech over the campus ethernet. Subsequently, the Intel ProShare systems were replaced with ImageLink systems and the test was again performed with satisfactory results. The audio and video quality of the ImageLink system was better than that observed with the Intel systems most likely due to the fact that ImageLink does not limit their upper bandwidth to 400Kbps as Intel does. It was agreed that either system could be used for the EHC project. In addition, it appeared that a stable ethernet CATV solution could be realized for this project; therefore, subsequent network design strategies focused on this approach.

The next step was to design a network for serving 25 patients, a nursing home, the nursing home director's (Dr. Jackson) home, two CMS units at MCG, and a CMS unit at EAMC. Although it was not necessary to select patients who currently have CATV service (Jones Intercable installed CATV in those houses that are not currently served), it was necessary to select patients in Jones Intercable Hub 0 service area. This is due to the additional cost and effort that would be required to outfit another head-end to accommodate ethernet CATV. A map of Jones Intercable Hub 0 was provided to the clinical subcommittee and it was agreed that for Phase I of this project, civilian and military patients in Hub 0 would be identified.

A complication arose in providing service to Dr. Jackson's home and to the CMS at EAMC because both sites are outside Jones Intercable Hub 0. It was agreed that Dr. Jackson's home could be served by fiber since Jones Intercable already had a fiber link that ran close to his home and a connection could be provided to Hub 0 via the local Martinez office. An investigation into providing service to EAMC was conducted with an initial focus on providing a fiber link to the ethernet CATV network. A backup plan was also being investigated in which ISDN lines would be used to connect EAMC to the network. After several weeks of investigation, it was determined that a fiber link to EAMC was too costly (~$40,000) and no commitment could be obtained from Jones Intercable to cover the cost of the fiber. The ISDN solution became the preferred method of connection and the process of installing lines at MCG was started. Three ISDN lines were installed at MCG while existing ISDN lines at EAMC were utilized. EAMC provided two Ascend Pipeline 400 BRI Inverse Multiplexors with ethernet support to be located at MCG and EAMC. This provided the capability of running TCP/IP and UDP over a 384Kbps link between MCG and EAMC. Since Intel ProShare limits their videoconferencing upper bandwidth to 400Kbps, it was felt that a bandwidth of 384Kbps would not noticeably affect the audio and video quality. Two network diagrams are provided in Appendix C. The first diagram represents a top level view of the physical network used for the EHC project while the second diagram provides a detailed overview of the network including IP addresses for the Zenith Home Works boxes and the EHC stations.

The first two installations were performed on February 26-27, 1996 within the Jones Intercable Hub 0 service area. Subsequent use of the system revealed that the network was highly susceptible to noise and fluctuations in signal levels. An investigation ensued to determine the cause of this interference and to stabilize the signal levels. A number of factors were revealed which were potential problems with the CATV network. Since this is leading edge technology, there is very little experience in the use of RF Modems to establish an ethernet network over the CATV system. There are a number of pilot projects underway in which this technology is being used; however, to our knowledge, this is the only application that is attempting to perform videoconferencing over such a network. Videoconferencing applications introduce extreme demands on the network and, as a general rule, require a pristine network to function properly.

Ingress Noise

Many articles have been published in recent months which describe difficulties encountered when implementing LANs over the cable network. The most serious of these problems is the entry of ingress noise into the system. Cable networks traditionally have a tree topology with the head-end being the trunk. The network branches as the distance from the head-end and number of customers increase. In the reverse path, each branch location represents a summing node for signals headed upstream. As a result, noise conducted or coupled into the reverse channel will be amplified and transmitted in the cable network. This noise causes the cable modem to behave as if the RF channel were unavailable. When the channel is not free, the modem will wait and try transmitting later. This method of retrying is unacceptable for real time data such as video packets. This problem manifests itself by the inability to receive video from the machine which transmits on the reverse channel (i.e. patient to nurse video traffic). There were numerous times during the project when a patient would be able to see and hear the nurse at the hospital, but the nurse would only be able to hear the patient with either no video or frozen video.

Ingress noise is difficult to measure due to the fact that it is typically bursty. As a result, a spectrum analyzer will indicate that a particular frequency is noise free, when in fact short bursts of noise are constantly on the network. These short bursts of noise, if of sufficient amplitude and duration, will collide with and destroy data packets. A method of quantifying the amount of noise on the network was devised and implemented. An RF modem was reverse engineered to extract the signal before and after processing. A filter was constructed to extract signals on the network which were less than 1.2us in duration and greater than .8Volts peak-to-peak. This filter allowed us to distinguish ingress noise from valid data since data packets are of longer duration. The goal was to identify bursty ingress noise capable of destroying valid data packets. When a burst of noise was detected by the filter, a signal was sent to a chart recorder which ran continuously. The bursty ingress noise was quantified by counting the number of bursts per second. Incidents of high activity were manifest by spikes on the chart recorder. While a relationship could be observed between the amount of ingress noise and the success or failure of a videoconference, no trends could be established in which ingress noise was expected to present. As a result, it became difficult to pinpoint the source(s) of this ingress noise.

While there exists expertise within Jones Intercable on RF modem technology, their experience is limited to applications outside videoconferencing. A two-day "workshop" was held on May 2-3, 1996 in which a Jones Intercable representative discussed the current state of the technology and the problems one could expect to encounter. Outside of acknowledging that ingress noise is a problem and that newer technology is becoming available which will handle this noise better, no concrete solutions were provided to address the immediate needs of the project.

Signal Levels

Reverse channel signal levels were another source of difficulty in realizing a stable network. It was observed that these signal levels would vary with the time of day and weather conditions. A method for measuring these signal levels at each home was devised and implemented. Pinging a specific RF modem at the patient location would result in packets being transferred between the two systems. A storage oscilloscope was attached to the CATV network and the trigger level was set to capture valid data packets. Once a valid data packet had been captured on the reverse channel, the amplitude of the signal could be measured. These measurements were performed at all patient homes four times daily. By observation, it was determined that if the signal level dropped below .8V peak-to-peak, then the chances of performing a successful videoconference were slim. As a result, the network was managed to keep all reverse channel signal levels between .9V and 1.5V.

The problem of ingress noise has been identified by both the cable companies and the cable modem manufacturers and is being addressed in the next generation of equipment. Nevertheless, this problem was one that could not be solved within the context of the EHC project but was instead managed to mitigate its effects. Also, within the requirements of the project, there could be a maximum of four simultaneous EHC consultations - one each from the MCG hospital, EAMC, the nursing home director, and the MCG lab. A schedule was developed such that only a single consultation would be in progress at any one time. This eliminated the chance that simultaneous conferences would negatively influence the network performance. In addition, a schedule was established in which the nurses were allowed to make patient calls during the morning and early afternoon; however, Jones Intercable was allowed to work on the network during the late afternoon hours. Jones Intercable constantly monitored the performance of the network and addressed problems as they were reported. In addition to addressing problems with ingress noise and signal levels, Jones Intercable personnel were continually wiring new patient homes to achieve the 25 patients called for in the Cooperative Agreement.

Protocol Issues

Protocols used for videoconferencing applications when combined with protocols used by RF modems compounded problems encountered with ingress noise. The Zenith HomeWorks modems are designed to buffer information and transmit in a First-In-First-Out fashion over the CATV network. If a collision is detected such that the packet is not successfully delivered to its destination, then the RF modem will try to retransmit up to 16 times. While the modem attempts to retransmit the data, the buffer is place on hold such that no new data is allowed to enter.

The Intel Proshare videoconferencing system uses UDP to transmit data between conferencing sites. This protocol releases the requirement of providing an acknowledge to the sending site that a packet has been successfully sent. The sending unit simply transmits packet after packet without regard for whether that packet successfully reached its destination. This protocol is used frequently in videoconferencing applications since the data is time sensitive and it does not make sense to retransmit packets that are old. If a packet comprising an audio or video stream were to be destroyed during transmission, the receiving system simply ignores that packet.

The effect of this is worse if the packet is an audio packet vs. a video packet since our perception of audio is much keener than our perception of video. In other words, a lost video packet is easier to conceal than a lost audio packet.

Regardless of which type of data packet is lost, it makes no sense to detect if that packet was lost and to retransmit it. In the time required to retransmit that packet, the videoconferencing system has completed that video frame or audio stream to which that packet belonged and would simply discard it. This difficulty is manifest in our application since the RF modem is programmed to keep re-sending data if a collision is detected. The end result is that the RF modem retransmits up to 16 times data which will eventually be discarded while preventing new data from entering the buffer.

If there is significant noise on the network, the RF modem will have to retransmit practically every packet that it receives 16 times. This slows the input buffer significantly to the point where the system sending data to the RF modem begins to overrun its input buffer. The result is that not only are packets that will be discarded retransmitted 16 times, new data that is trying to enter the input buffer is lost. A situation can exist in which the system fails to the point that it cannot recover if significant noise exists on the network. Researchers investigated the possibility of having Zenith modify their code in the RF modem so that it would not try to retransmit; however, there was little interest on Zenith's part to perform this modification. Their engineering staff were focusing on developing the next generation modems and were unwilling to support the current generation of RF modems to the point of modifying code for this project.

Summary

While a pristine network environment was never realized during Phase I of the project, the network problems were successfully managed such that the nurses were able to videoconference with their patients in most cases. The network is still susceptible to ingress noise which occasionally will render the network unusable. In addition, fluctuations in the signal levels as a result of the weather conditions will cause instability in the network. These problems are being managed on an on-going basis by Jones Intercable personnel.

Each Electronic House Call system is provided with a unique IP address and system number. This unique IP address allows the use of TCP/IP and UPD as the transport protocol on an ethernet network. It uniquely identifies each patient and directs the videoconferencing call to the appropriate CMS. The system number with the IP address allows remote software management from any system on the network.

Subsequent efforts in Phase II will focus on deploying the next generation cable modem equipment which will handle the problem of ingress noise more efficiently. Frequency hopping capabilities will allow the modems to continuously monitor the network searching for "clean" channels on which to transmit. While there is no guarantee that this will result in a pristine network, the promise of a much improved network is promising. There may still exist difficulties with regard to network protocols involving videoconferecing that need to be addressed with cable modem providers and/or manufacturers of videoconferencing equipment.

System Development

Hardware

The consortium agreed to develop a custom computer-based telemedicine system after an extensive search of commercial home telemedicine systems revealed that there was no system which could meet the goals of the project. It was also agreed that the Intel ProShare videoconferencing system would be used for videoconferencing and that the Johnson & Johnson Dynamap system would be used to monitor physiological parameters. It was felt that the hospital grade monitoring equipment was much more reliable than the component based approach which consisted of low-cost devices for patient use. There was concern that some of the component systems were not acceptable for diagnostic purposes and questions arose regarding FDA approval of these devices.

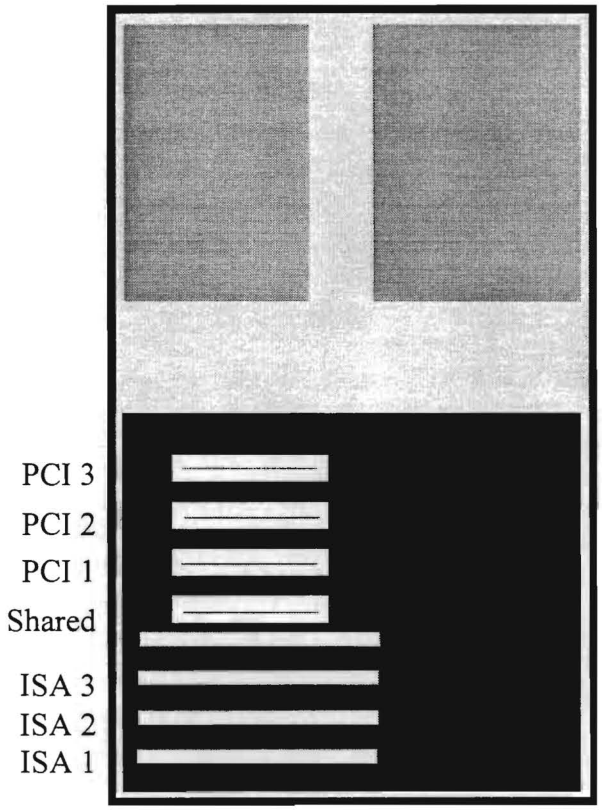
The technical subcommittee began developing a system which would integrate these components, provide network functionality, and provide the patient with a turn-key medical monitoring solution. The final system configuration is shown in the block diagram provided in Appendix D. It was agreed that a high performance prototype system would be developed with little regard to the initial cost. Subsequent development efforts will focus on providing acceptable functionality while reducing the cost of the system. As technology improves, the cost will naturally come down; however, there many avenues for cutting cost particularly if collaborative arrangement can be established with component vendors.

The Electronic House Call consists of two systems, Patient Monitoring Station (PMS) and Central Monitoring Station (CMS), connected over a cable network. The "heart" of each system is the computer and all associated components used in the EHC are connected through the computer. The following paragraphs will describe in detail the individual components comprising the CMS and PMS.

- **Dell XPS-P120C** - The Dell personal computer has a Pentium-based microprocessor with an internal speed of 120 Megahertz (MHz). It is configured with 32 Megabytes of Random Access Memory (RAM) and a 1.6 Gigabyte hard drive. There are four 32-bit PCI expansion-card slots and four 16-bit ISA expansion-card slots. The computer can accommodate up to seven cards (ISA and PCI) since one slot is a shared slot. It also has two serial ports and one directional parallel port. It has a standard 3.5" floppy drive and a 4X CD-ROM drive. It comes standard with a PS/2-style keyboard and PS/2-compatible mouse. It also comes standard with a pair of Altec Lansing speakers.

  The computer also comes equipped with SoundBlaster 16-bit audio board factory installed. It is capable of playing all (.wav) files used in the EHC software. The computer is subsequently configured with various boards that allow videoconferencing, ethernet, and expanded serial port capabilities. Figure 1 shows the internal configuration of the Dell XPS120C and indicates the location of all expansion cards.

- **Matrox Video Board** - The Matrox Millennium video board is a PCI-type board. It has the advantage of a 64-bit VGA-compatible graphics engine which provides fast graphics and video acceleration. It is a 2 MB VRAM board with a maximum desktop size of 1600X1200 pixels with 8 bits per pixel color resolution. In the EHC system, it uses 24 bits per pixel with a resolution of 800x600. This provides the highest color scheme possible with approximately 16 million colors and a large desktop resolution. The maximum refresh



Internal View of the Dell XPS-P120C

PCI 3 - Empty
PCI 2 - Matrox video board
PCI 1 - 3-Com Etherlink III board
Shared - GTEK serial port board (PMS only)
ISA 3 - Sound Blaster 16-bit audio board
ISA 2 - Reserved
ISA 1 - ProShare Audio/Video board

Note: ISA 2 is reserved for the ProShare ISDN board if ISDN is the mode of communications employed

Figure 1. Dell XPS-P120C Internal Configuration

rate is 72 Hertz for 24 bits per pixel.

A Diamond Viper Pro Video card was initially used in the EHC system on the recommendation of Intel; however, it was discovered that the system would frequently crash with this card installed. Many times this crash occurred over night when no one was working with the system. After many hours of tracking down the problem, it was discovered that the Diamond Viper Pro card is not compatible with Windows '95. Within a short time after our discover, Diamond Multimedia released a statement to the effect that their Viper Pro card is not compatible with Windows '95. As a result, we switched to the Matrox Millennium card which performed well with Windows '95.

- **3Com Ethernet board** - The 3Com EtherLink III BusMaster board provides the TCP/IP and UDP capability over a Ethernet LAN network. The board has a RJ-45 jack for a 10Base-T ethernet cable. It supports a maximum bandwidth of 10 Mbps. This card is used when the EHC system is operated in the LAN mode. If ISDN is chosen as the mode of communications, this board is not populated. A separate Intel ProShare ISDN board is place in slot ISA 2 for ISDN communications.

- **GTEK Serial board** - The GTEK ISA serial port expansion board provides four additional communication serial ports to the existing two that are provided with the Dell XPS 120C. It has the capability of sending and receiving data at 460,800 bits per second per channel.

The four port connectors can accept any RJ-45 plug. The GTEK board also comes with the BBS Guardian Watchdog circuit which provides automatic reset of the computer in the event of a crash. The Watchdog basically performs a poling of the hard drive to determine if the system has crashed. The reset wire from the Dell computer is routed onto the GTEK board and therefore automatically provides the resetting of the computer in the event of a crash.

The GTEK board is only used on the patient computer (PMS) in the EHC. It provides a communication port for the Crikiton Dinamap Vital Signs Monitor and a means for recovering from a hardware failure. One limitation of the Watchdog is that it does not detect software failures. It has been our observation that in the vast majority of cases when the system fails, it is the software that has crashed and not the hardware.

- **SoundBlaster Audio board** - The SoundBlaster 16-bit audio card comes pre-installed in the Dell XPS120C computer. This card is used to play back .wav files in providing instructions to the patient as well as supporting the electronic stethoscope via its line-in port.

- **Intel Proshare board** - The Intel Proshare 150 Videoconferencing board is a full-length, single slot, 16-bit ISA board. It has four audio input/outputs and two separate video inputs. The four audio inputs are Line-In/Line-Out and Microphone/Headphone. The audio inputs are mutually exclusive, if Line-In is chosen Line-Out is chosen automatically. The two video inputs are a S-VHS Y/C input and a composite video input. Intel Proshare supports various network protocols including IPX and TCP/IP. It also supports numerous standards including the H.320 videoconferencing standard and T.120 data conferencing standard.

  The Intel videoconferencing system provides the capability to capture images from the patient site and download them to the CMS. The image quality was compared with similar systems offered by other manufactures of videoconferencing equipment as well as stand alone video capture boards. The image quality, when compared with other systems, was inferior; however, it is believed that the quality is of sufficient quality for our application. As clinicians use the system, the validity of this assumption will be determined. Provisions have been made in hardware for the addition of a video capture care should the image quality prove to be unacceptable.

- **ELO Monitor** - The ELO monitor is a 17 inch, non-interlaced touchscreen monitor. The touchscreen provides an easy user interface for the EHC system. It has a fine dot pitch of 0.27 mm and a maximum resolution of 1280X1024. The monitor is also anti-flare, anti-reflection, and has a anti-static coating for better focus, contrast, and color performance. It has an automatic scan rate of 30 kHz to 65 kHz for the horizontal frequencies and 50 Hz to 110 Hz for the vertical frequencies.

  In the Electronic House Call, the ELO Touchscreen monitor is used with a resolution of 800X600 and a scan rate of 60 Hz. The touchscreen is controlled through a serial port communication on the computer. It is connected into serial communications port 1 (COM 1) on the computer.

- **Canon Camera -** The Canon Communication Camera VCC1 provides panning, zooming and auto focus capability through a wireless infrared remote or through a computer. The camera outputs a NTSC video signal which is fed directly into the Proshare board as described above. The camera also has audio capability with a microphone and audio output which is not currently being utilized. The camera has both manual and automatic focusing capability. Automatic focusing is currently being used in the EHC system. The camera is controlled through a RS-232 port which is connected to the computer via serial communications port 2 (COM 2).

- **Coherent Call Port -** The Coherent Call Port is a desktop audioconferencing system. The Call Port is a full-duplex, omni-directional microphone/speaker system. It has adaptive echo cancellation and active noise cancellation. It has a frequency response of 200 Hz to 3.4 kHz for the transmit and receive levels. It is equipped with a RS-232 microphone/ headphone harness that is connected into the 1/8 inch microphone/headphone jack on the Proshare board. The Call Port is also equipped with a Line-In/Line-Out harness that is not being used. Two versions of the Call Port are being used because the manufacturing specs changed between the time the first and last batches were purchased. The newer Call Port's have software that can be downloaded onto the system to obtain optimal performance for specific types of videoconferencing being used. A trade-off is that the volume control buttons have been replaced with mute and echo cancellation buttons which can be confusing to the nurses. While the nurses could instruct the patients to decrease or increase the volume on the old Call Ports, doing so on the new call ports will cause the volume to be muted or echo cancellation to be toggled on and off. More than once this has resulted in failed videoconferences due to the fact that the Call Port audio was muted.

  In the Electronic House Call, the Call Port provides easy, hands-free operation of a full-duplex speaker/microphone system. The EHC systems that are equipped with software dependent Call Port's have been optimized to work with the Intel Proshare Videoconferencing System. In practice, no difference in the audio quality has been detected between the old and new Call Ports.

- **Zenith Cable Modem** - The Zenith HomeWorks Universal Cable Modem provides a solution for connecting ethernet-based computers over a broadband cable medium. The modem has four connectors: one RS-232, one 10Base-T, and two broadband "F" type. The two broadband "F" type connectors provide connection to the CATV. The 10Base-T connector provides connection to the computer system utilizing ethernet communications. The cable modem has a bandwidth of 4 Megabits per second and a frequency response between 50-550 MHz. It has LED indicators for packet collisions on the broadband side, RF activity, and transmit and receive data.

  The Zenith Homeworks Universal cable modem provides a way of connecting two EHC systems together over the CATV system. Each modem and EHC system is assigned a unique IP address. The RF modem can be queried over the network to retrieve status information and to set parameters. The 3Com Ethernet board, installed in the computer, is connected to the cable modem by a RJ-45 (10Base-T) cable.

- **Critikon Dinamap** - One of the factors critical to the success of the EHC project was the ability to incorporate a vital signs monitor into the PMS in a manner transparent to the patient. It was decided that it would be confusing for the patient to be required to operate a piece of medical equipment as well as the touchscreen. The vital signs monitor needed to be embedded in the system, had to provide the results of measurements and allow the host computer to control certain aspects of the instrument's operation. The Dinamap Plus 8720 fulfilled these requirements through both its default operation as well as the its Host Communications protocol.

The Crikiton Dinamap Plus 8720 provides many of the vital signs monitoring capabilities in the EHC system - pulse oximetry, temperature, ECG, and blood pressure. It can be controlled by a host computer via a RS-232 port. It has full-duplex, serial communications with a data rate of 9.6kBps. The Dinamap is equipped with audible alarms for out-of-range measurements.

Two minor modifications had to be made to the Dinamap to facilitate seamless integration into the PMS. The EHC system was designed such that all the components' power switches would remain in the on position, and power to the entire system would be supplied through a single master switch. As initially configured, the Dinamap would not reactivate when line power was removed and reapplied to its power supply. It also required the user to press the on button again. To circumvent this problem, the contact beneath the Dinamap on switch was shorted to ground. This simulated a user pressing the on switch and operated as desired. In addition, the internal speaker of the Dinamap was disconnected to prevent unwanted alarms from being heard.

<u>Pulse Oximetry</u> - The NellCore Pulse Oximetry is designed to noninvasively monitor oxygen saturation and pulse rate. The transducer can be switched from an adult to infant pulse oximeter without re-configuring the Dinamap. Oxygen saturation is measured in the change in relative transmission of infrared and red light passed through the tissue.

<u>Temperature</u> - The YSI 400 temperature probes are used with the Dinamap. The Dinamap has a single channel input with a lay temperature in Fahrenheit or Celsius. The probes take approximately five time constant to reach 99% of their total change in temperature. The probes are made of stainless steel for durability. They have a measurement range of 0 to 70 degrees Celsius with a tolerance of +-0.1 ^{o}C. The probes need to be sterilized and disinfected for proper functionality.

<u>ECG</u> - The Dinamap has a three-lead ECG built-in. It is capable of displaying single-lead waveforms. It also has the capability for "Lead Off" error messaging and audible alarms for lose of electrical continuity. The leads are color-coded for easy placing. The data is streamed through the data port to the computer for reconstruction on the computer. The waveform can be displayed at one of three sweep speeds (12.5 mm, 25 mm, or 50 mm per second). The ECG waveform can also be used to calculate heart rate.

From the EHC perspective, there are both similarities and significant differences in the EKG measurement as compared with the other parameters. The Dinamap begins recording an EKG waveform once all three leads have been attached. The host can control which EKG lead is being recorded and displayed through the an ASCII command which increments the current monitor lead. (If the current lead is lead III, this command will set the monitor lead to lead I.) EKG data, unlike the other measurements, is reported in binary format. The host directs the Dinamap to send a continuous stream of binary data and then must unpack and reconstruct the EKG waveform from the flow of binary blocks as specified by the Dinamap Plus Host Communications Reference manual. Under this arrangement, the Dinamap continues sending binary data until instructed by the host to stop.

Blood Pressure - The Dinamap uses the oscillometric technique to monitor noninvasive blood pressure and to display systolic and diastolic pressure, mean arterial pressure (MAP) and pulse rate. It is also capable of sensing cuff size and switches automatically between adult to neonatal or vice versa. It also has automatic and manual operating modes.

Blood pressure determinations are started and canceled under control of the host. The Dinamap Host communications protocol includes ASCII commands for starting and canceling a determination. The Dinamap interprets the commands, either inflates or deflates the blood pressure cuff, and responds whether the operation was successful. To obtain the blood pressure reading, a non-invasive blood pressure status command is issued to the Dinamap. The response gives status information which tells if there has been an error or if the measurement is still proceeding. If the determination has completed successfully, the systolic pressure, diastolic pressure, and mean arterial pressure are contained in the response string.

- **MTI Stethoscope Send Unit -** The MTI stethoscope send unit is equipped with a electronic stethoscope, send unit, headphones, and power cord. The send unit is a amplifier which takes the stethoscope input, boosts the signal, and outputs a line level output. This output is linked into the Line-In on the Proshare board with a 1/8" cord. The send unit also has a local headphone output for a standard 1/8" plug. The stethoscope has a bell which can be turned to listen for lung or for heard sounds. The amplification on the send unit needs to be adjusted so that there is no clipping on the output. A gain of 75 V/V was used to adjust the send unit. The input voltage was 60 mV (p-p) and the output voltage was 4.5 V (p-p). The MTI send unit was placed with the patient monitoring system.

- **MTI Stethoscope Receive Unit -** The MTI receive unit is equipped with a equalizer that takes a line level input and output a headphone level output. The Line-Out of the Proshare board on the CMS was taken into the equalizer for optimization and then a pair of Andries Tek stethophones were used as the headphones.

  The receive unit was removed from the system due to lack of performance and the Andries Tek stethophone was placed directly into the Line-Out of Proshare.

- **Bush Cart** - The Bush Computer cart holds all the components of the Electronic House Call. A cart was needed that could be functional, transportable and easily usable. The Bush

4209A computer cart comes unassembled although assembly is easy. There are two slide out trays provided with the cart. The top-most, long tray was used to hold the diagnostic devices for the PMS and the keyboard, mouse, and Andries Tek for the CMS. The middle tray was removed in mini-tower computer systems due to space. Flat computer systems utilized the middle tray to hold the Critikon Dinamap and the stethoscope send unit. The middle tray was not used on the CMS. A black plexiglass door was added on both systems to conceal the interior parts of the Electronic House Call.

Clinicians emphasized the importance of lighting from the beginning and this has been a difficult problem to address. The objective has been to achieve a lighting situations similar to that used by a professional photographer without blinding the patient. A number of solutions have been sought with little success. The final system configuration uses a soft-white fluorescent light mounted on top of the monitor. The success or inadequacies of this solution will be determined as clinicians use the system to monitor patients in which lighting plays an important role in an accurate assessment. Phase II efforts should address lighting concerns raised by the clinicians as well as procedures for obtaining accurate color representations.

The hardware configuration for the prototype EHC telemedicine system has been finalized. A detailed procedure has been established for configuring the hardware for both the PMS and the CMS. This written procedure is provided in Appendix E.

Much work remains in reducing the cost and size of the system and it is hoped that these concerns can be addressed during Phase II of the project. The vision of the technical research team is to develop a television set-top box which will provide the functionality identified above using the patient's television as a display monitor and a remote control to interact with the system.

Software

Software developers from the Interactive Multimedia Technology Center (IMTC) were contracted to provide a patient and care provider interface for the EHC telemedicine system. IMTC staff worked closely with BITC researchers and clinicians at MCG to define the software requirements for the system. As the software was used by clinicians and patients, many bugs were discovered and subsequently addressed. Researchers within BITC modified the software in response to problems reported by users and several updates were released throughout the project. A major software update was performed during the first week of August which represented the final version under Phase I. This version of the software provided a much more stable platform and addressed many of the problems encountered by clinicians and patients. Although the software is generally stable, there are still requests, primarily from clinicians, for updates in the code. Occasionally, the software experiences a failure due to errors encountered in the database functions. Software efforts under Phase II will address these problems as well as investigate the possibility of porting the code to a more robust language such as C.

The current software design balances the requirements to control many features with the need to keep the user interface simple enough for a non-technical patient to use unassisted in their home. The entire focus is on bringing medical care into the patient's home without sending a care provider. Thus, the patient will be running the system, and the first and foremost goal is to make it easy to use.

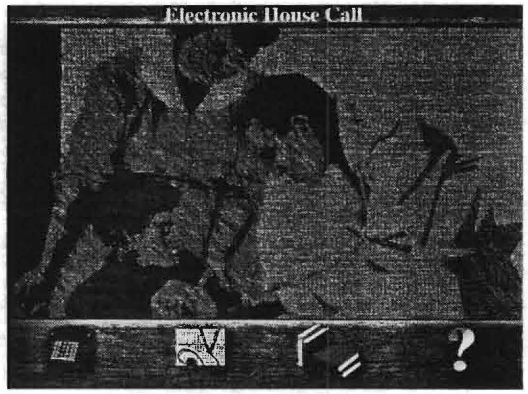


Figure 2. Patient Monitoring Station
Home Screen

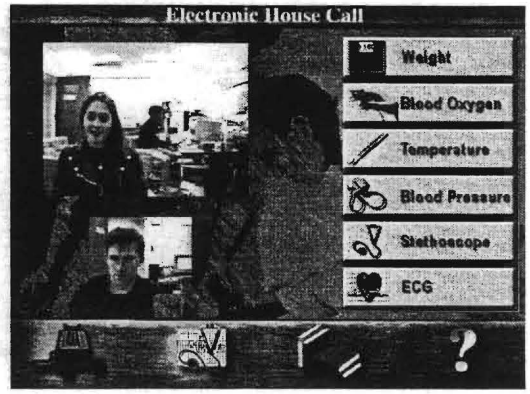


Figure 3. EHC Videoconferencing Screen

The Electronic House Call software is written in 16-bit Visual Basic 4.0 running on Windows 95 operating system with the hardware requirements given. There is a seamless integration of four major functions: communications (audio/video/data), data acquisition, database management, and camera control. These four major components are within the underlying software therefore there is a transparent integration of all the components. PDK's (Programmer's Developers Kit) provide customized user interface which can be incorporated into a custom application. The communication aspect is provided by the Proshare PDK 2.0 (Programmer's Developers Kit). This provides live two-way video, full-duplex audio, data channels, and file channels. The data acquisition is provided by the Johnson & Johnson Dinamap PDK. A communication's port on the computer allows for data collection of the pulse oximetry, ECG, blood pressure, and temperature. This data is then transmitted through the data channel to the receiving end. The database is constructed in Jet Database Engine 2.5. It provides data management, storage and retrieval. The camera control is provided by Canon VCC1 PDK. This provides control of the camera's power/ pan/zoom features.

Software for the Patient Monitoring Station (PMS)

The software design for the patient station is based on a central home screen from which the user initiates actions, and to which the user will always return after completing a task. The patient will quickly become familiar with this home screen and will be able to return to this screen from most program levels at any time. The home screen, shown in Figure 2, consists of only four icons and selections are made by touching the screen. The four options, represented by picture icons, that the patient can select are: 1) a phone icon initiates the video conference connection to the central monitoring station, 2) a stethoscope and chart icon initiates vital signs measurements, 3) a stack of books icon initiates a medical information search, and 4) a question mark icon initiates on-line help.

- **Video Conference Call To The Central Monitoring Station**

The call button on the patient's home screen provides the videoconferencing link to the hospital. The patient then touches their name from a patient list to initiate the call. The receiving party must agree to accept the call. Videoconferencing is supported through

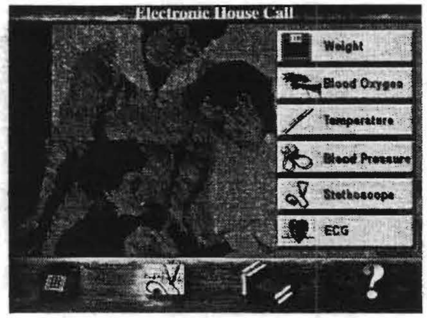


Figure 4. Main Vital Signs Menu

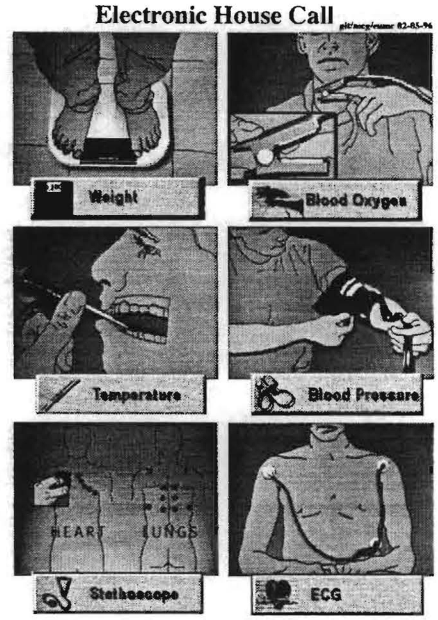


Figure 5. Initial Screen For Each Vital Signs Measurement

software calls to the Intel ProShare videoconferencing software PDK as described above. Once the call is accepted at the receiving end, the video, audio, and data channels are opened to provide live two-way communications. Two video windows are displayed one top of each other. The top window is larger in size and contains the video from the CMS. The bottom window contains the local video so that the patient can view the image that is being sent to the CMS. The videoconference screen is shown in Figure 3. If the central monitoring station is busy, the patient will not be able to connect. The consortium agreed that for the Phase I pilot study, patients would be instructed to use conventional emergency procedures (911) to obtain care under emergency situations. Phase II enhancements will notify the CMS that a new call is coming in and allow the CMS to handle multiple calls.

- **Vital Signs Measurement**

If the patient selects the vital signs icon, a menu of options will be displayed on the right side of the screen as shown in Figure 4. The patient will touch the screen to select which measurement is desired. Each on-line videoconferencing measurement taken is automatically transmitted to the CMS. For each measurement, the screen displays written step by step instructions and an illustration showing how the device should be used. The initial screens presented to the patient for each diagnostic measurement are shown in Figure 5. A recorded voice paraphrases the written instructions each time a measurement is initiated. In addition, the patient can select more help by touching the "Tell Me More" button. This feature plays back an audio/video clip showing the measurement steps and procedure necessary to take an appropriate measurement. All audio/video clips are stored as (.mov) files to be played back on Apple's QuickTime Player. The medical devices currently supported include:

1. Stethoscope for heart and lung sounds - transmitted as audio via line level input in

Proshare
2. ECG - transmitted via data channel in Proshare
3. Pulse Oximetry - transmitted via data channel in Proshare
4. Weight - transmitted via data channel in Proshare
5. Temperature - transmitted via data channel in Proshare
6. Blood Pressure - transmitted via data channel in Proshare

Measurements can be taking during a live video conference or taken off-line, when there is no video conference. In either case, the measurement values are stored in a local database, and automatically transferred to the central monitoring station. In the event of an error during the reading of a measurement, audio/video clips describing the problem and all the possible causes of that problem are shown.

- **Medical Information Resources**

The stack of books icon provides the patient with a link into supporting information applications as shown in Figure 6. Currently, an AMA CD-ROM with medical information is initiated when this option is chosen, but the plan is to expand this utility to provide Internet access to dynamic medical information sources and patient support groups.

- **Main Help**

On-line help is provided to the patient by selecting the question mark on the home screen. A simple overview of the EHC project and basic instructions are currently displayed, but the software is designed to include still images, audio, and video clips where appropriate. This type of multimedia help is already provided on subscreens of the vital signs measurements.

<u>Software for the Central Monitoring Station (CMS)</u>

The Central Monitoring Station for the Electronic House Call provides the care provider with videoconferencing and data display tools in a Windows 95 environment. The EHC program is started by double clicking the EHC icon on the Windows desktop. A control window and menu bar present the commands. Figure 7 illustrates the CMS screen with various windows representing an audio/video conference, a patient list, local and remote camera control, and patient stats. A menu bar is provided which can be used to invoke many of the CMS functions as well as perform standard Windows operations such as Exit, Open a File, Save, etc.

- **Patient List**

Upon starting the EHC on the CMS, a patient list is shown. This list consists of all the patients that the CMS can do consultations with. There are six options within this patient list - information for a patient, statistics for a patient, placing a call to a patient, testing a patients connection, adding a new patient, deleting an existing patient. All operations on this patient list are controlled through the Jet database.

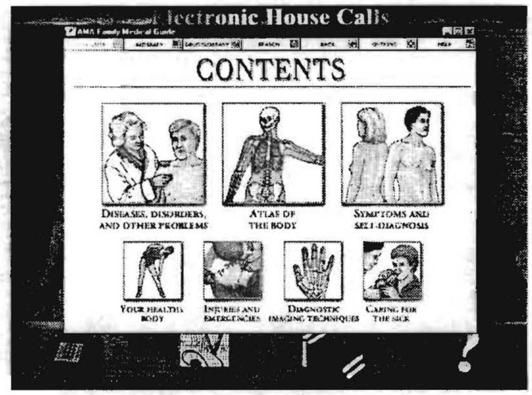


Figure 6. Medical Information (AMA Family Medical Guide) Screen.

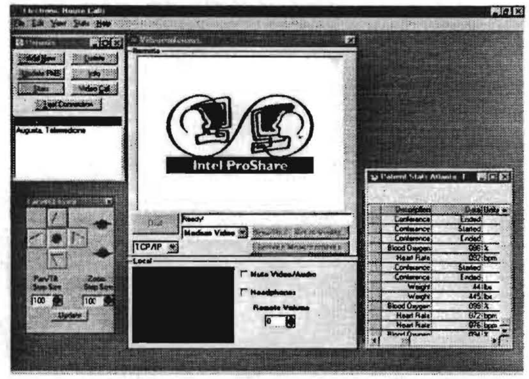


Figure 7. CMS Main Screen With Video Window, Patient List, Camera Control, And Stats.

Information on a patient include address, phone number, system number, IP address, ISDN address and relevant doctor information. Patients can have similar system numbers, IP addresses and ISDN numbers since multiple patients can be accommodated at a PMS.

Once changes are made to the patient list, they are transferred to the PMS via the data channel.

- **Making A Video Call**

Video calls are placed by hitting the "Video Call" button. This initiates a call to the patient's system. Calls are directed to the appropriate systems by the IP address that is associated with each patient. Once the call is accepted at the receiving end, Proshare plays live video and audio. The data and file channels are also opened for transferring of measurements.

- **Controlling The Remote Camera**

The CMS software also has controls for panning and zooming of the CMS camera and the PMS camera. This panning capability lets the nurse obtain the patient in the correct field of view and also to check if the patient is correctly placing the diagnostic devices. The zooming capability allows the nurse to zoom onto skin lesions, bruises, etc. The controls can also be fine tuned to move in finer detail or for coarse panning or zooming of objects. The Canon camera has both video output and a serial output for control. All commands are sent through a serial port on the computer to the camera. The camera output is fed into the Proshare card, described in the hardware section. The camera power is also turned off after each call so save the LCD within the camera.

- **Initiating Remote Measurements**

All six of the measurements described above can be controlled by the CMS. The CMS can initiate any measurement and cancel any measurement at any time. These commands are sent through the Proshare data channel to the PMS. The PMS interprets the input data and processes it to start the correct measurement. Measurements can only be started one at a time and any attempts to start another measurement cancels the previous measurement and starts the new measurement.

- **Taking Video Snapshots**

The CMS is also capable of taking snapshots of the remote image. There are two kinds of snapshots: regular snapshot and high-resolution snapshot. The regular snapshot is a compressed image obtained directly from the CMS. The high-resolution snapshot is an uncompressed image transferred over the data channel directly from the PMS. This uncompressed image provides higher resolution and finer detail. Both images can be saved into a patient's database for future viewing.

- **Reviewing Data In Database**

The patient measurements and images are stored in the patient's "Stats". A patient's statistics includes the time/day stamp, type of measurement, data taken, and any comments about the measurement. All videoconferences, images, and off-line measurements are also recorded in the "Stats". All off-line measurements are tagged as off-line measurements in the comments box. Any measurement can be deleted from the Stats.

Other Software Needed To Run Electronic House Call

The Electronic House Call package uses a Quicktime Movie Player to display the help videos on the Patient Station. The current implementation initiates the AMA CD-ROM application as a medical information resource. Intel's ProShare video conferencing hardware and software is incorporated into the Electronic House Call system to support the videoconferencing and data transfer options. The ProShare Developers Kit was used to create a customized user interface to the ProShare videoconferencing tools.

Electronic House Call Video/Audio Help Scripts

Help scripts are provided for the patient to guide them through the use of each diagnostic device. When the user initiates a measurement, the associated screen consists of a set of written instructions as well as voice instructions for proper use of the diagnostic sensor. If the user is still unsure as to the proper use of the sensor, pressing the "HELP" button will bring up further explanation via voice and video clips. The following paragraphs detail the instructions and scripts used to assist the patient in using the diagnostic sensor.

- **Blood pressure**:

Instructions:

1. Secure cuff on arm just above elbow.
2. Position arrow at inside elbow pointing toward hand.
3. Sit still in comfortable position with arm on rest.

4. Select start and wait for measurement to complete.

Illustration:

arrow on cuff in position on arm.

Video Voice Script:

You are about to begin your Blood Pressure measurement. This is like the blood pressure measurement in your doctor's office. If your clothing is covering your upper arm, you will need to remove it in order to get an accurate reading. Next, slide the blood pressure cuff around your upper arm just above your elbow. Position the cuff so the arrow on the cuff is on the inside of your arm, opposite to your elbow. The arrow should be pointing down your inner arm toward your hand. The cuff is secured by Velcro and will expand during the measurement. Sit in a comfortable position with your arm resting on a support at about heart level. The arm on your chair or sofa would provide good support, or you can use a pillow or cushion to achieve the same result. During the measurement, the cuff will expand and become tight for about thirty seconds. This may be uncomfortable, but the tightness will release very soon after the measurement is completed. If at any time it becomes unbearable, you can select stop to quit the measurement and loosen the cuff. When you are ready to begin the measurement, sit in a comfortable position and select Start. Please remain still during the measurement. You will be alerted when the measurement is complete. If you want more instructions, select "Tell Me More".

Tell Me More Script:

The blood pressure cuff should be ready to slide onto your arm at the beginning of the measurement. If you have problems with the cuff, you may need to adjust the Velcro position. To do this, pull apart the Velcro and wrap the cuff around your arm so that it fits somewhere between loose and snug. It should not be tight, but it should not be so loose that it falls easily off of your arm.

Error Script:

An error has occurred during the blood pressure measurement. Please make sure that the cuff is positioned and secured correctly. Remember to remove any clothing covering your arm. Also avoid restricting the blood flow by rolling up a sleeve. During the measurement, you must remain quiet and still. Noise or movements can disrupt the signal. After checking to make sure that everything is set up correctly, try starting the measurement again. If a second unexplained error occurs, stop the measurement and report the problem to the monitoring station.

- **Pulse Oximeter**

Instructions:

1. Select index finger with clear healthy nail.
2. Clip sensor on finger with cable along back of hand.
3. Push finger into sensor until it stops
4. Sit still in comfortable position.
5. Select start and wait for measurement to complete.

Illustration:

Hand with oximeter in position on index finger with cord out over top of hand and pads in full contact. Finger tip against stop.

Video Voice Script:

You are about to measure your blood oxygen level with a pulse oximeter. This is done with a small sensor that interprets a light shining through your finger nail. The sensor clips comfortably on your finger and you will not feel any pressure or heat from the light. Before you start, make sure that your hands are clean and dry. Normally you will place the clip on your index finger, but you should choose another finger if the index finger is injured or has a discolored nail. The finger you choose must not have any bandages or artificial nails. If you have on nail polish, you will need to remove it before continuing. Place the sensor clip on your finger with the finger tip against the stop. If you have long finger nails, they should extend over the stop. Make sure the sensor is positioned so that even force is applied over the length of the pads. The cable of the sensor should run along the top of your hand. Sit in a comfortable position and begin the measurement by selecting Start. The measurement takes between fifteen and thirty seconds to stabilize. Please remain still during the measurement, and you will be alerted when the measurement is complete. If you want more instructions, select "Tell Me More".

Tell Me More Script:

Pulse oximetry can have problems when a finger or nail is damaged, discolored, or suffering from poor circulation. In these cases another finger should be chosen. Most finger nails can fit inside the sensor if they are positioned correctly over the top of the finger stop, however, extremely long nails may need to be clipped before the sensor can be used.

Error Script:

An error has occurred during the pulse oximetry measurement. Please make sure that the sensor is positioned correctly. However, if the sensor is too tight, this could also cause erroneous values. Remember that the finger must be clean and dry, and there should be no nail polish or any other covering on the finger. The finger should be healthy with a clear nail. Avoid fingers with poor circulation, and avoid fingers that are bruised under the nail. During the measurement, you should remain quiet and still. You should not have anything on that would restrict the blood flow to your finger (no blood pressure cuff and no rolled up sleeves). It is possible that bright light can interfere with the measurement, and if you're not sure you can cover the sensor with a towel. After checking to make sure that everything is set up correctly, try starting the measurement again. If a second unexplained error occurs, stop the measurement and report the problem to the monitoring station.

- **Temperature**

Instructions:

1. Do not eat or drink for twenty minutes.
2. Place sterile sleeve over temperature probe.
3. Position temperature probe under tongue.
4. Keep probe under tongue during measurement.

5. Select start and wait for measurement to complete.

Illustration:

Probe under tongue in cutaway of mouth.

Video Script:

You are about to take your Body Temperature. Have you had anything to eat or drink in the last 20 minutes? If so, your temperature measurement may not be accurate. To determine your body temperature, find the temperature probe provided. Put a clean plastic sleeve over the end of the temperature probe. Position the probe under your tongue and as far back as you can without discomfort. When you are ready to begin the measurement, sit in a comfortable position and select Start. Remember to keep the probe in place until the measurement is finished. You will be alerted when the measurement is complete. If you want more instructions, select "Tell Me More".

Tell Me More Script:

Some temperature probes may look different from the one shown in the first video illustration, but they will function in the same way.

Error Script:

An error has occurred during the temperature measurement. Please make sure that the temperature probe is positioned correctly under your tongue. During the measurement, you must keep the probe under your tongue. After checking to make sure that everything is set up correctly, try starting the measurement again. If a second unexplained error occurs, stop the measurement and report the problem to the monitoring station.

- **Stethoscope**

Instructions:

1. Place flat white side of stethoscope directly on skin.
2. Hold stethoscope in position as directed.
3. Sit still and remain quiet during measurement.
4. Be sure not to move fingers holding stethoscope.
5. Select start and wait for measurement to complete.

Illustrations:

Positions on chest for heart sounds
Positions for lung sounds on chest
Positions for lung sounds on back
Close-up picture of switching stethoscope to "flat white side"
Close-up picture of stethoscope's "flat white side" (membrane)

Video Voice Script:

You are about to record your heart and lung sounds using a stethoscope in much the same way as your doctor would. The electronic Stethoscope provided with your system records heart and lung sounds and transfers them to the monitoring station. The measurement is made by placing the flat white side on the stethoscope directly on your skin. You can hold the stethoscope inside a loose gown or cover-up, but you need to remove any under garments so that the stethoscope contacts the skin. You will normally be guided by someone at the monitoring station while you position the stethoscope, but these diagrams show some of the standard positions for the listening to the heart and lungs. Before starting, make sure the stethoscope is switched to the white measurement side. Relax in a comfortable position. It is important that you remain still during the measurement and that you do not move your fingers holding the stethoscope. The monitoring station will initiate the measurement if they are guiding you, or you can initiate the measurement by selecting Start. The measurement will last for ten to twenty seconds, and you will alerted when it is complete. If you want more instructions, select "Tell Me More".

Tell Me More Script:

The electronic stethoscope on your system should always be switched to the flat white side. If it is not in this position, the heart and lung sounds cannot be measured correctly. You can verify that the stethoscope is set correctly by looking closely at the small hole in the center of the "bell" on the opposite side from the white surface. While holding the bell in one hand, grasp the short shaft leading to the wire in your other hand. As you roll shaft between your thumb and index finger, it clicks into two distinct positions. Now observe the hole in the center of the bell as you roll the shaft. In one position, the hole is shallow, and in the other position, the hole is deeper. To use the white surface for measurements, the stethoscope should always be in the shallow position. You might also notice that the shaft is angled toward the bell side, and away from the white surface when it is in the correct position.

Error Script:

An error has occurred during the stethoscope measurement. Please make sure that the stethoscope is switched to the correct position for measurements through the flat white surface. It is also important to make sure the stethoscope is in direct contact with the skin and that you remain quiet and still throughout the measurement. After checking to make sure that everything is set up correctly, try starting the measurement again. If a second unexplained error occurs, stop the measurement and report the problem to the monitoring station.

- **ECG**

Instructions:

1. Prepare skin surface as instructed in Help video.
2. Place adhesive patches as directed.
3. Snap wires onto patches: black to upper left, red to upper right, white to lower left.
4. Sit still and remain quiet during measurement.
5. Select start and wait for measurement to complete.

Illustration:

electrode sites diagram w/ - red, white, and black - onto snaps on adhesive patches

Video Voice Script:

You are about to make an ElectroCardiogram, or ECG, measurement. The ECG records heart signals through three wires that are attached to adhesive patches on your skin. You will feel no heat or current during this measurement, and the most irritating part is in removing the adhesive patches at the end. You will normally be guided by someone at the monitoring station while you position the patches, but these diagrams show some of the standard positions. The best measurements are made when the patches are in an area that is free of hair, and you may be asked to shave a small area where a patch will be placed. Clean the area with alcohol and make sure the skin is completely dry. Then, peel off the back of the adhesive patch and stick the patch onto your skin. There are colored snaps on the end of the ECG wires that will connect the wires to the metal button in the center of each patch. Snap the black connector to the patch near your upper left shoulder, the white connector to the patch on your upper right shoulder, and the red connector to the patch on your lower left side (just above your waist). You are now ready to begin your ECG measurement. The monitoring station will initiate the measurement if they are guiding you, or you can initiate the measurement by selecting Start. The measurement will last for ten to twenty seconds, and you will alerted when it is complete. If you want more instructions, select "Tell Me More".

Tell Me More Script:

ECG measure electrical activity in the heart. The adhesive patches that are placed on the skin form an electrical contact with the body, and that is why it is important for the skin to be clean and free from hair at the locations where the patches are attached. There are different types of ECG measurements that can be made. For this system, the standard measurement will be made while you are in a sitting position, and the patches are placed near your shoulders and on your side. Other types of measurements may be requested by the monitoring station, and they can guide you during a video conference for those measurements.

Error Script:

An error has occurred during the ECG measurement. ECG can be negatively affected by incorrect position of the patches, improper preparation of the skin, or movement during the measurements. Please make sure that the patches and the electrodes are properly attached. During the measurement, you must remain quiet and still. Noise or movements can disrupt the signal. After checking to make sure that everything is set up correctly, try starting the measurement again. If a second unexplained error occurs, stop the measurement and report the problem to the monitoring station.

- **Weight:**

Instructions:

1. Place scale on hard flat floor surface.
2. Stand on scale dividing weight evenly on both feet.
3. Report weight measurement as directed

Illustration:

Scale with feet in position to step on scale

Video Voice Script:

You are about to make a weight measurement. Weight changes can provide important information about your health status, and you may be asked to make regular measurements on your own or to make a measurement during a conference with the monitoring station. Use the scale provided with your system to measure your weight. Be sure the scale is on a hard flat surface before weighing. Select start to record the results.

Tell Me More Script:

Error Script:

An error has occurred during the weight measurement. Please make that the scale is placed on a hard flat surface. After checking to make sure that everything is set up correctly, try starting the measurement again. If a second unexplained error occurs, stop the measurement and report the problem to the monitoring station.

Electronic House Call Database

An rudimentary patient database is provided to catalogue patient information and vital signs. Information regarding vital signs is entered into this database each time the patient takes a measurement irrespective of whether they are currently in a videoconference. The care provider can access this information in graphical or text format. Graphical representations are very useful in viewing trend data. Textual comments as well as video images can also be stored.

There are two parts to the database. The "main" database is stored on the CMS, containing past measurements, patient information, doctor information, and PMS phone numbers/addresses. There is a database on the PMS for the purposes of storing patient information, as well as holding off-line measurements until the database is automatically synchronized with the CMS (a description of the synchronization process is below). With the exception of measurements, all EHC information is entered into the database at the CMS.

There are four types of information being stored in the EHC database:

- Information about Central Monitoring Stations (CMS)
- Information about Patient Monitoring Stations (PMS)
- Doctors' information
- Patients' information
- Synchronization queue

Off-line transactions are defined as transactions with the database that occur while a videoconference is not in progress. On the CMS, off-line transactions include:

- Adding/Deleting patients and/or doctors
- Adding/Deleting PMS units and/or their addresses/phone numbers
- Viewing/Deleting past measurements from a PMS.

On the PMS, off-line transactions are:

- Taking measurements

When off-line transactions take place, the local database is changed and a record of that change is stored in a "queue" (an ordered table containing the change), along with an address for which PMS/CMS site the change should be sent to. Every so often (the interval can be set by the user) during "idle" time (i.e., not videoconferencing), the EHC program on the CMS/PMS checks to see if there are any records in the queue. If there are, the EHC software initiates a connection with the first PMS/CMS unit in the queue and proceeds to send the changes to be made to that unit. As each change is received and performed, the receiving unit responds with a handshaking signal to indicate that the change was successfully made. When a confirmation from the other computer is received, that record is deleted from the queue. If the confirmation is not received, the record is skipped and is saved for a future attempt. This approach ensures that no data is lost due to garbled communications, software crash, etc.

On-line transactions are defined as transactions with the database that occur while a videoconference is in progress. On the CMS, on-line transactions include:

- Viewing/Deleting past measurements from a PMS.

On the PMS, on-line transactions are:

- Taking measurements

All on-line database transactions occur on the CMS database. When a measurement is taken, the PMS transmits the data to the CMS immediately for storage in the CMS database. The CMS operator is then able to view/delete the measurements while on-line.

System Installation

The first two EHC Patient Monitoring Stations were installed in patient homes on February 26-27, 1996. One patient was an EAMC patient and the other an MCG patient. Both systems were tested upon installation by linking with the CMS in their respective hospitals. The connection with the MCG hospital appeared to work well; however, when connecting to EAMC, the return video from the patient was frozen most of the time and the audio was breaking up. Jones Intercable was notified of the problem and began to investigate the cause of the poor connection. After two weeks of working on the problem, Jones Intercable could find no problems in the CATV system which would cause a poor connection with the EAMC patient. Efforts began to identify software, hardware, and network issues that could contribute to the problem.

Georgia Tech researchers began to address problems with the software as they arose and focused efforts on a major software revision that would result in a more stable platform. This software revision would solve many of the database problems that were being encountered as well as allow patients to perform off-line measurements properly. The old software allowed patients to perform off-line measurements; however, the results were not being transmitted to the CMS. In addition, the old database structure did not accommodate multiple patients and did not allow for multiple CMSs to serve one location as required by the nursing home site.

Researchers at Georgia Tech, MCG, and the Center For Total Access (CTA) began to address problems from a network standpoint and ran a series of tests on the Ascend inverse multiplexors. Technical support from Ascend was solicited and it was discovered that several parameters were incorrectly set on the Ascend inverse multiplexor. Adjusting these parameters solved one problem which prevented us from initiating a call from the MCG side of the network; however, the quality of the audio and video were not changed. It was unclear whether the poor audio and video were a result of the CATV system, the ISDN lines, or a combination of the two.

An investigation into characterizing the CATV network from a signal level and noise standpoint ensued. Researchers at MCG devised a method for measuring bursty noise on the line which was empirically related to the success or failure of a videoconference. MCG began recording noise activity on the CATV system on a 24 hour basis. The hope was to identify trends in the noise such that particular times could be identified when the noise was expected to be great. This would allow Jones Intercable to track down the source of the ingress noise and eliminate it. Unfortunately, the occurrences of noise on the network appeared to be random and no trends could be established. This information, however, was used to determine if a videoconference would be successful so that the nurses could avoid connecting with patients during times of high ingress noise. In addition, the information could be used to explain a poor connection after the fact.

It was also discovered that if the signal level were low on a particular CATV run, then the videoconferencing quality with a patient on that run would be poor. This was the case for the first EAMC patient installed in which the video and audio were unacceptable. Subsequent tests with different signal levels indicated that if the signal level fell below .8V peak-to-peak, then the videoconferecing quality would be unacceptable. It was agreed that MCG would monitor the signal levels to all patient homes four times daily. If the signal level to any home fell below .8V, then Jones Intercable personnel would be notified and would address the problem immediately.

CTA personnel concentrated on solving apparent problems with the ISDN connection between EAMC and MCG. A testbed system was established between the hospital at EAMC and a laboratory at CTA. Tests were conducted in which Intel Proshare alone was run and compared with the quality of the EHC system which has Intel Proshare imbedded in it. There appeared to be no difference in the quality; however, it was discovered that the audio and video quality were better when operating in "smoother" mode. Intel Proshare has two modes in which one can operate. "Sharper" mode utilizes 400Kbps of bandwidth and the video resolution is set at FCIF (352X288). When operating in "Smoother" mode the video resolution is set to QCIF (176X144) and utilizes only 200Kbps of bandwidth. The "Smoother" mode sacrifices video resolution to gain better video motion (i.e. a faster frame rate). Feedback from the nurses indicated that a faster frame rate was more desirable than better video quality; therefore, the decision was make to operate the EHC system in "Smoother" mode. This resulted in substantial improvements in the video motion over the MCG/EAMC ISDN link. As a result, the EAMC nurse was able to visit with patients more reliably from EAMC.

Installations of Patient systems from March through July included six EAMC patients, two MCG patients, and the nursing home. All CMS systems serving civilian, military, and nursing home patients had been installed by the end of May. The patient installation schedule was reduced significantly from the original plan due to problems encountered with the software and difficulties in maintaining a stable network. It was determined that further installations should be halted until a stable network and software platform could be achieved.

The major software revision was completed during the last week of July and scheduled for installation during the week of August 5. Although the elimination of ingress noise had not been achieved, a means for managing it as well as coordinating the debug activities of Jones Intercable around patient visits had been achieved. The reverse channel signal levels were being managed using the established procedure of monitoring them four times daily and reporting any problems to Jones Intercable. A technical committee meeting was held on August 5 in which it was suggested that the installations move forward with the new software version and methodology in place for managing the network. It was agreed at that meeting that all EHC systems would use the lower resolution video to achieve a greater frame rate allowing military patients to be visited from EAMC. In addition, Georgia Tech agreed to have someone available "on-call" in the Augusta area Monday through Friday to address technical problems.

The installation of patient systems proceeded on a rapid pace following the software update and concluded on September 30, 1996 with 16 patient systems serving 24 civilian and military patients, and one nursing home. One military patient system was removed; however, this was deemed an installation since data was obtained regarding that patient. A single installation occurred on October 7, 1996 as well as the removal of a system from a civilian patient's home, which maintained the same number of systems and patients. All CMS units have been installed and are currently operational.

Appendix A

TECHNICAL REVIEW OF HOME HEALTH CARE TELEMEDICINE SYSTEMS

GEORGIA INSTITUTE OF TECHNOLOGY
BIOENGINEERING CENTER

Background

The Bioengineering Center, in conjunction with Eisenhower Army Medical Center and the Medical College of Georgia, has evaluated three home health care telemedicine systems that appeared to offer promise for use in the Army funded telemedicine program. The potential systems were selected for further evaluation at Ft. Gordon through an extensive search involving advertisements on the world wide web, postings to relevant newsgroups, and telephone conversations. The three systems evaluated were:

- Health Tech Services, Corp. - HANC
- H.E.L.P. Innovations, LC - Resource Link
- American Telecare, Inc. - PTS100S

Various other teleconferencing/telemedicine systems were investigated and deemed not appropriate for our application. These systems included

- VTEL, Inc. - DeskMax
- Data Point, Inc. - MINX 2000
- AT&T - Picasso
- MD/TV
- British Telecom - VC7000 and VC8000

The following discussion will center on the three systems which appeared to be most relevant to our project and were evaluated extensively via demonstrations (Health Tech and American Telecare) and presentations (H.E.L.P. Innovations) at Ft. Gordon. A brief description of each demonstration and/or presentation will be given followed by a discussion of the advantages and disadvantages of each system as it relates to objectives defined early by the consortium. Finally, the three systems will be compared with each other to determine the most appropriate direction for the consortium. A recommendation will be provided which will represent our best understanding of the current state-of-the-art and will allow us to rapidly deploy home-based systems.

Health Tech Services, Corp. - HANC

Representatives from Health Tech included Fred Orkin, Kathleen Crampton, Steve Kaufman and Mike Glynn. The meeting opened with a brief discussion of the consortium's purpose and goals. This was followed by a discussion by Health Tech representatives concerning their business structure and market strategies. From a business standpoint, Health Tech seemed to be well positioned to carry forward the deployment and support the future development of HANC. A prototype HANC system was brought to Ft. Gordon for demonstration to the consortium. It appeared that HANC is currently in a prototype stage and that production units have not been made. Representatives from Health Tech indicated that it would take approximately six months to manufacture units for delivery. It is our understanding that Health Tech has capital available to make possible the manufacture of HANC units. If this is not the case, it could seriously limit the time require to obtain units and tremendously impact the cost of each unit.

HANC is a PC-based system which provides communication between the home and a central station via standard telephone lines. Currently HANC is capable of monitoring blood pressure, temperature, EKG, and heart and lung sounds of home-bound patients. HANC's software has been developed primarily from the standpoint of medication reminding and guiding the patient through a diagnostic procedure. Issues regarding HANC that are relevant to our project are listed below.

1) *Two-Way Audio/Video* - HANC does currently support this; however, it is over a standard phone line and is therefore very "jerky" (3-5 frames/minute). Mention was made with respect to implementing ISDN, Switched-56, etc. for better video and the comment was made that "it does not matter which medium you use, HANC could work over it." While this may be true in the long term, it is not as simple as it was made to sound. The software necessary to compress/decompress audio and video under the current standards must be developed and integrated into HANC. Should ethernet over cable be the preferred means of transport, the packet drivers to support ethernet must also be developed and integrated into the HANC software.

2) *Architecture* - Currently HANC is an open architecture system supporting JPEG compression of video images. Some talk was made regarding fractal compression to increase the frame rate over the telephone line. This is possible; however, if such a compression algorithm is used, the system becomes proprietary and therefore not compatible with other vendors. There is currently no standard which supports fractal compression of images.

3) *Software Database* - The HANC system software was developed in C++ under the OS/2 operating system. The software allows the patient to store and retrieve diagnostic information as well as send the information to the central station. In addition, the software supports image capture, compression, storage and forwarding to the central station. The future of the OS/2 operating system is uncertain and experience has indicated that it is riddled with bugs. No standard database software was used to develop a patient record. It would appear the a standard database front-end such as Paradox or Access could be used to link with an Oracle database at the central station and would operate under a Windows environment.

4) *Diagnostic Instrumentation* - HANC currently supports the monitoring of blood pressure, heart and lung sounds, EKG, and temperature. It was suggested that HANC could support any diagnostic instrument that has an RS-232 port. While this is probably true in the long run, it is not as simple as it was made to sound. For each diagnostic device added, software must be developed to interface with the device, acquire data, store the data, and display it in a meaningful form.

5) *Patient Education* - HANC currently supports assisting patients in remembering to take medication and in performing diagnostic procedures. While HANC does not support patient education from a clinical information standpoint, the addition of a CD ROM and extended software capabilities could allow for this type of patient education. Additional work in increasing the bandwidth would allow for patient-specific data to be transmitted over the

telecommunications link.

6) *Image Capture and Camera Control* - HANC employs a relatively low resolution camera (240 X 480 - 12 bit color) that is mounted on a goose neck. The patient positions the camera and then backs away to take a still image. If voice recognition is not used, the ability to press a key or touch the screen while removed from the camera and remaining still is difficult to achieve.

7) *User Interface* - The prototype HANC system supports a touch screen for patient interaction. Text-based icons were used to direct the patient to obtain information or perform a diagnostic procedure. Health Tech representatives stated that voice recognition would be added to the system and would be the preferred method of interaction. They indicated that this would be a speaker independent system and would be accurate enough for home use. This is a bold statement knowing the state-of-the-art in voice recognition systems. Although much progress has been made over the past several years, voice recognitions systems are not 100% accurate and will often times misinterpret the command if it is not said exactly as before. This is especially true with speaker independent systems with large vocabularies. We must be sensitive to this fact and consider the chance for failure and the patient's subsequent frustration with the system. If the commands are chosen carefully and the patients do not have a significant accent, then the voice recognition interface approach may work well. In addition to its potential for being unreliable, voice recognition will add considerable cost to the system.

8) *Multi-point Conferencing/Support Groups* - HANC currently does not support this.

H.E.L.P. Innovations, LC - Resource Link

Representatives from H.E.L.P. Innovations, LC included Linda Roman and Rose___. Mr. Jacob Maezuga from Kansas Innovation, Corp., an economic development, state-funded organization, also attended the meeting. A brief overview of the proposed Army funded effort was given by representatives from Georgia Tech and Ft. Gordon. Ms. Roman then presented an overview of the company, its inception, current status, and relationship to Kansas Innovations. Resource Link is currently being used to monitor elderly patients in a nursing home and home environment. The University of Kansas is using this system in a pilot project in which four homes are connected to a central station located at a hospital. Ms. Roman indicated that system could be available within 90 days from the time an order is placed.

Resource Link provides real-time, two-way audio and video between the home-bound patient and a central station. This is achieved via the CATV coaxial cable system which requires close cooperation with the local cable company in outfitting its central office for two-way audio and video. The hardware required to achieve this was not discussed but would most likely be similar to what Jones Intercable plans to have available for our demonstration project. Resource Link is heavily dependent on audio/video and does not currently have a data path. Any diagnostic information is either read off the instrument by the patient or shown to the attending nurse at the central station. The company is investigating the possibility of presenting data over the horizontal blanking interval of the video signal as is currently done in transmitting closed-caption data on a television screen. This may present an acceptable solution for interfacing with diagnostic devices and transmitting data back to a central office. It could also be used for transmitting patient specific or general data to individuals at home, although such transmissions would be slow.

Resource Link is not currently a PC-based system so the ability to access or transmit data is limited to only what can be presented with video and audio. The patient has no ability to interact with screen. A database has been developed for the central station to chart patient information; however, an attendant is required to enter the data manually. As the patient presents diagnostic data to the attendant, either through reading off the digital value or holding the device up to the camera, the attendant keys the data into a PC-based database. Issues regarding Resource Link that are relevant to our project are listed below.

1) *Two-Way Audio/Video* - Resource Link supports high quality two-way audio and video via a CATV connection. They support picture-in-picture such that one can see what they are transmitting and receiving simultaneously. They currently do not support a data path which is a limitation for our application, especially if we are using a diagnostic instrument that does not have a digital display of the result. Representatives indicated that they are addressing this issue by exploring the possibility of using the data path inherent in all CATV channels.

2) *Architecture* - Resource Link supports any video camera and monitor system that could be placed into the home. From this perspective, it is an open architecture system and the use of an in-band CATV data path would also conform to standards since this path is frequently used for closed caption data. Any modifications to the system as a result of adding a PC for data capture, storage and tracking can be done such that the system conforms to current standards. On the other hand, there are very few teleconferencing/telemedicine systems currently on the market (DataPoint) that handle video in the same manner; therefore, only a limited number of current systems are compatible with Resource Link. Future modifications could correct this, particularly if ethernet over CATV is used rather than analog video.

3) *Software Database* - A software database exists only at the central station and patient information must be entered manually. The in-band data path that is currently being investigated could provide a hook into this database. The database at the central station could be enhanced such that patient specific or general information can be made available to the patient though audio and video paths. This database is PC-based; however, it is not known which language was used to develop the database and how easily expandable it is.

4) *Diagnostic Instrumentation* - Any diagnostic instrumentation which has a digital readout is supported through the video link. The patient is required to either read the digital value or hold the device up to the camera so that the attendant can read the value. Currently, the system has been used for monitoring Temperature, Pulse, Blood Pressure, Blood Glucose Level and Weight. This is not an automated process and therefore is cumbersome for the patient and attendant. There is currently no method for supporting diagnostic instrumentation that does not have a digital readout.

5) *Patient Education* - This is not currently being supported by Resource Link; however, the PC system at the central site could be modified to transmit general or patient specific information to the individual. This could be achieved by adding a CD ROM jukebox with specific CDs prepared for particular illnesses. The attendant would select which information

to transmit and the appropriate audio/video sequence would be selected from the prepared CDs and transmitted to the patient. There is currently no capability for the patient to select the desired information.

6) *Image Capture and Camera Control* - Image capture or remote camera control is not currently supported by Resource Link. Image capture could be achieved by adding an image capture board to the central station's PC. Software would be required to direct the computer to perform the image capture and store the image relative to the patient. Since Resource Link provides an NTSC video link at full motion (no blurring of the image), the images capture should be of sufficient quality to perform some diagnosis although NTSC is not considered a high resolution image format.

7) *User Interface* - The home-based Resource Link system does not support a user interface. The patient is notified by a series of beeps when a connection is being established by the remote attendant. A platform at the patient site for developing a user interface does not currently exist. The capability for the patient to contact the central office and request a video teleconference is accomplished via a regular phone call. In the event that the patient experiences and emergency, a remote alert device will call the central office directly.

8) *Multi-point Conferencing/Support Groups* - Resource Link does not currently support multi-point conferencing.

American Telecare, Inc. - PTS100S

Representatives from American Telecare included Dr. Khalid Mahumud and Joleyn Young. The meeting was begun with a presentation by Dr. Mahumud regarding the product, status of the company, market decisions, and direction. This was followed by a demonstration of their complete system connected between conference rooms. Representatives from Georgia Tech and Ft. Gordon then discussed the proposed project identifying potential applications for which the PTS100S may fulfill.

PTS100S is a video phone based system with standard analog phone connection between the home-bound user and the central station. The system is based around the MCI video phone which is supported by a vacuum formed module incorporating diagnostic instrumentation and an external speaker/microphone. Currently the PTS100S supports an electronic stethoscope (proprietary) and a blood pressure cuff although a separate analog phone line is required. Any diagnostic instrument having a readout can be supported by having the patient read the value or hold the device up to the camera. The video phone allows one to transmit live video, although very slow, as well as capturing and forwarding images. The video screen is very small and difficult to see (approximately 3.5" X 3.5").

The PTS100S system is currently being used in 10-15 homes primarily in monitoring diabetic patients. A special adapter attaches over the camera which magnifies the image as well as holds a syringe so the remote attendant can observe the amount of insulin drawn into the syringe. Admittedly, the camera image is poor and could not be used for diagnostic procedures involving small lesions. The company's position is that further enhancements in the system would add significantly to the cost thus rendering the system cost prohibitive. The system's cost is approximately $4,500. The company intends to sell the system to health care providers who will establish a network consisting of a central station and patient homes.

Internal research efforts are focused on removing the requirement for a second phone line to support the electronic stethoscope. In addition, Dr. Mahumud indicated that they intended to support a data link between the home and the central station as well as provide the capability to display video on a PC monitor at the central station. American Telecare is cautions however regarding modifications that would add to the cost of a home-based station.

Calls to the patient's home are scheduled throughout the day. Should the attendant call and the patient not respond, the external speaker/microphone is activated after 8 rings so that the attendant can correspond by voice. The sensitivity is such that the attendant should be able to hear the patient located in another room possibly calling for help.

1) *Two-Way Audio/Video* - PTS100S supports this through a standard video phone provided by MCI. Since the video is transmitted over standard analog phone lines, the quality of the video is poor (8-10 frames/second). In addition, the video screen is extremely small and therefore difficult to see. No plans were expressed for upgrading the video at the home-based station; however, they intend to display video on a PC monitor in the near future.

2) *Architecture* - The system uses a standard telephone line for transmission; however, in order for the patient and attendant to share video, a PTS100S system must exist at each site. The MCI phone uses a proprietary algorithm for compression and decompression and therefore could not communicate with other video/telemedicine conferencing systems.

3) *Software Database* - An extensive software database has been developed for the central station using Microsoft Access, a Windows-based database program. Extensive menus have been developed such that patient data can be entered, stored and tracked. In addition, they have developed approximately 75 guidelines for providing treatment into the home.

4) *Diagnostic Instrumentation* - PTS100S currently supports any diagnostic instrument that has a digital readout. The patient must hold this up to the camera or read the value to the attendant. In addition, a proprietary electronic stethoscope is provided but requires an additional telephone line for use. Standard equipment supplied with the base PTS100S system consists of a MCI video telephone, electronic stethoscope, blood pressure cuff, and an external speaker/ microphone. American Telecare indicated plans for providing a data path; however, this would be primarily for transmitting data from the central station to the patient. There were no indications that American Telecare was interested in efforts to provide automatic data collection and transfer to the central station.

5) *Patient Education* - The subject of patient education is not addressed by the PTS100S. This concept was not discussed with representatives, although the presence of a data link might make it possible to transmit general or patient specific data to the individual. Given this capability, it is doubtful that the patient could read the information due to the small screen. The presentation of video instruction over this link would be more distracting than helpful due to the poor quality of the video.

6) *Image Capture and Camera Control* - The PTS100S does support the capability of capturing video images and transmitting them to the central station. The image capture is actually performed at the central station which requires that the remote attendant position the patient, via voice commands, in front of the camera and then take an image. The image quality is poor and can only be used for viewing gross lesions or posture. Since there are no plans to move away from the video telephone, improvements in this are unlikely.

7) *User Interface* - The user interface at the home site is cumbersome due to the small screen size. If one wants to magnify the image for viewing a syringe, a special adapter must be placed over the camera. There does not exist a software database allowing the user to select options at the home site. The central site consists of a PC-based database with well structured patient records. These records appeared to be easily accessible; however, all information must be entered manually.

8) *Multi-point Conferencing/Support Groups* - PTS100S does not support multi-point conferencing.

Recommendation

Discussions during the development stage of the proposal focused on live two-way audio and video interaction with the home-bound user. Initial design plans were presented which utilized a Sun workstation with a cable TV-based ethernet connection. Due to the fact that a Sun or Silicon Graphics Workstation was initially specified, software development was to be done in X-Windows, a graphical programming environment, to allow the user to interact with the system. Jones Intercable had agreed to outfit their central office such that two-way audio and video was possible using ethernet. Off-the-shelf diagnostic instrumentation would be interfaced to the Workstation through serial and/or parallel ports. The resultant system would be capable of interfacing with diagnostic instrumentation having a serial or parallel interface, transmitting real-time two-way audio and video, collecting and cataloguing patient data, providing the patient access to general as well as patient specific information, and would be controlled via a graphical user interface. The integration of off-the-shelf diagnostic instrumentation would be accomplished by GIT and Andreas Tech using equipment provided by Andreas Tech. The development of a graphical user-friendly interface would be accomplished by GIT and AND, Corp.

The discovery of several companies currently providing home health delivery via telecommunications indicated that we should seriously investigate systems that are being used and look at the potential for rapid deployment of that system with subsequent development efforts to advance the state-of-the-art. It was not anticipated that one company would have all of the capabilities that we desire in an end-product; however, the existing product would provide a platform onto which we could build. The possibility of involving the telephone companies in this endeavor as well as the cable companies presents an attractive arrangement. Our primary goal is to provide quality health care into the home without concern for the telecommunications link; however, the link that is used must be capable of reaching the majority of the population. Since telephone lines extend into almost everyone's home, this is an attractive communications link; however, current deployment limits one to very low bandwidth and therefore poor quality video and slow data channels for transferring patient information. On the other hand, cable TV is fairly widespread, although not as predominant as phone lines, and offers a tremendous improvement in bandwidth. This improvement in bandwidth offers high quality video and the ability to transmit general as well as patient specific information quickly.

The consortium must investigate both technologies for providing quality health care into the home. This makes sense from both a practical standpoint due to the capabilities and limitations that each technology affords and a political standpoint to position Georgia in the forefront of home health care delivery. To this end, our recommendation is that we pursue a working relationship with both Health Tech and H.E.L.P. Innovations. It is believed that rapid deployment of both systems can be achieved and that improvements in both systems would substantially advance the state-of-the-art. Health Tech's goal, with direction and assistance from the consortium, would be to improve upon the software currently developed to allow for access to general and patient specific information, to allow for better presentation and tracking of diagnostic information, to develop a more attractive user-friendly interfaced, and to increase the bandwidth capability including support of CATV. H.E.L.P. Innovations' goal, again with direction and assistance from the consortium, would be to improve upon current audio and video capabilities by adding a PC-based interface to diagnostic instrumentation, adding an in-band data path for transmitting data, developing a graphical user-friendly interface for collection, storage and tracking of patient information, and developing an interface for retrieving general and patient specific information. Additional efforts on both fronts would center around providing multi-point capabilities to allow for patient "support groups" in the form of multi-point conferencing.

Appendix B

ELECTRONIC HOUSE CALLS

PROJECT REVIEW MEETING

November 29, 1995

MEDICAL PARAMETERS

- EKG Rhythm Strip
- Electronic Stethoscope
- Pulse Oximeter
- Blood Pressure
- Temperature
- Weight
- Spirometry
- Blood Chemistry
- Doppler Ultrasound

MEDICAL DEVICES

- Dynamap - Johnson & Johnson - $6,300
  - Blood Pressure
  - Pulse Oximetry
  - Heart Rate
  - ECG
  - Temperature
  - RS-232 Computer Interface
- LifeWatch - Ralin Medical - $1,000
  - ECG Wrist Watch Device
  - Heart Rate
  - RS-232 Computer Interface
- Onyx - Nonin - $350
  - Pulse Oximetry
  - Heart Rate
  - Visual Display of Parameters

MEDICAL DEVICES

- PALCO/8500- Nonin - $600
  - Pulse Oximetry
  - Heart Rate
  - RS-232 Computer Interface
- HealthDyne - ?
  - Pulse Oximetry
  - Heart Rate
  - Parallel Computer Interface
- DynaPulse - $800
  - Blood Pressure
  - Heart Rate
  - PC board with automated pump
- ThermoScan - $75
  - Temperature (Tympanic)
  - Visual Display of Temperature

MEDICAL DEVICES

- Andrias Tek
  - Electronic Stethoscope
  - Cardiac and Lung Sounds
  - Analog Input to Computer
- Stethocom II - MTI
  - Electronic Stethoscope
  - Cardiac and Lung Sounds
  - Analog Input to Computer
- TelePhonic Stethoscope - American Telecare - $1,500
  - Electronic Stethoscope
  - Cardiac and Lung Sounds
  - Analog Phone Line

AUDIO/VIDEO TELECONFERENCING

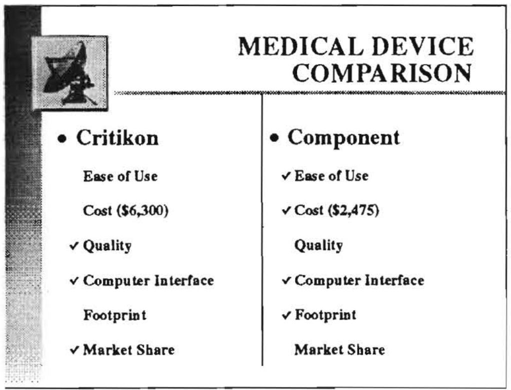
- Intel ProShare - $2,550
  - Ethernet Support (ISDN Support Optional)
  - Limited to 400Kbps (Equivalent to 128Kbps ISDN)
  - Provides Software Developer's Tools for Third Party Applications
  - Includes:
    CODEC Card
    Audio "Call Port" Speaker/Microphone
    PCI Accelerated Graphics Card
    Ethernet Card
    Low Quality Camera
  - Picture-in-Picture Capability
  - Integrated Document and Application Sharing
  - Integrated Still Image Capture

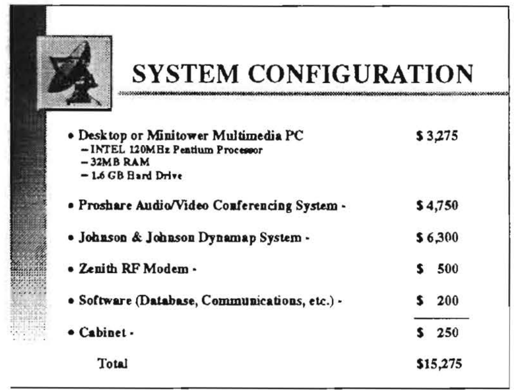
AUDIO/VIDEO TELECONFERENCING

- ImageLink - $4,750
  - Ethernet and ISDN Support
  - Limited to 2Mbps
  - Provides Software Developer's Tools for Third Party Applications
  - Includes:
    CODEC Card
    Speaker/Microphone
    Video/Graphics Overlay Card
    Ethernet Card
    Low Quality Camera
  - Picture-in-Picture Capability
  - Third Party Document and Application Sharing
  - Third Party Still Image Capture

VIDEO SYSTEM COMPARISON

• Intel	• ImageLink
Image Quality	✓ Image Quality
Audio Quality	✓ Audio Quality
✓ Cost ($2,550)	Cost ($4,750)
✓ Software Tools	✓ Software Tools
✓ Document Conferencing	Document Conferencing
✓ Market Share	Market Share

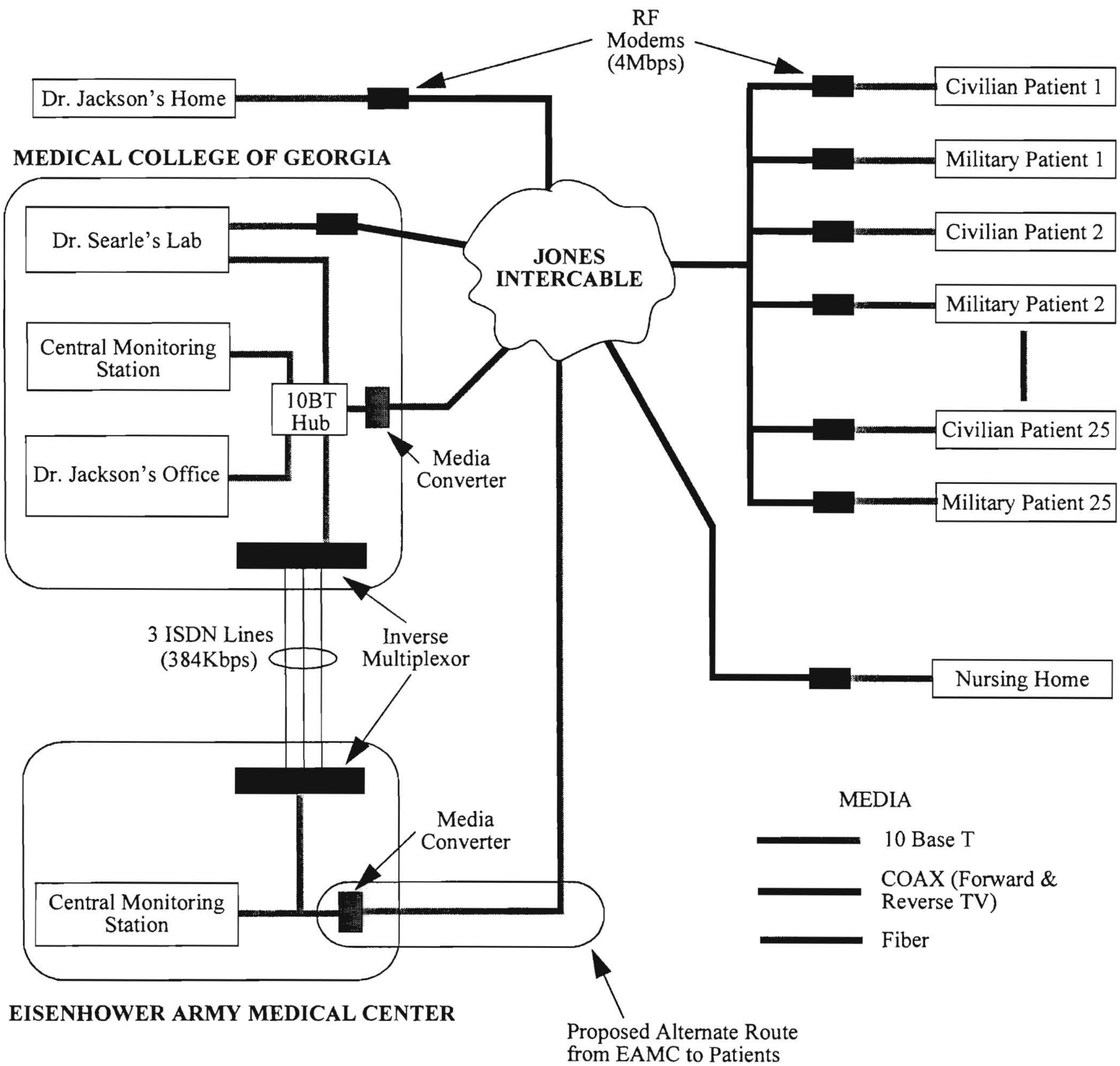

MEDICAL DEVICE COMPARISON
• Critikon
Ease of Use
Cost ($6,300)
✓ Quality
✓ Computer Interface
Footprint
✓ Market Share
• Component
✓ Ease of Use
✓ Cost ($2,475)
Quality
✓ Computer Interface
✓ Footprint
Market Share


SYSTEM CONFIGURATION
• Desktop or Minitower Multimedia PC $3,275
– INTEL 120MHz Pentium Processor
– 32MB RAM
– 1.6 GB Hard Drive
• Proshare Audio/Video Conferencing System - $4,750
• Johnson & Johnson Dynamap System - $6,300
• Zenith RF Modem - $ 500
• Software (Database, Communications, etc.) - $ 200
• Cabinet - $ 250
Total $15,275

Appendix C

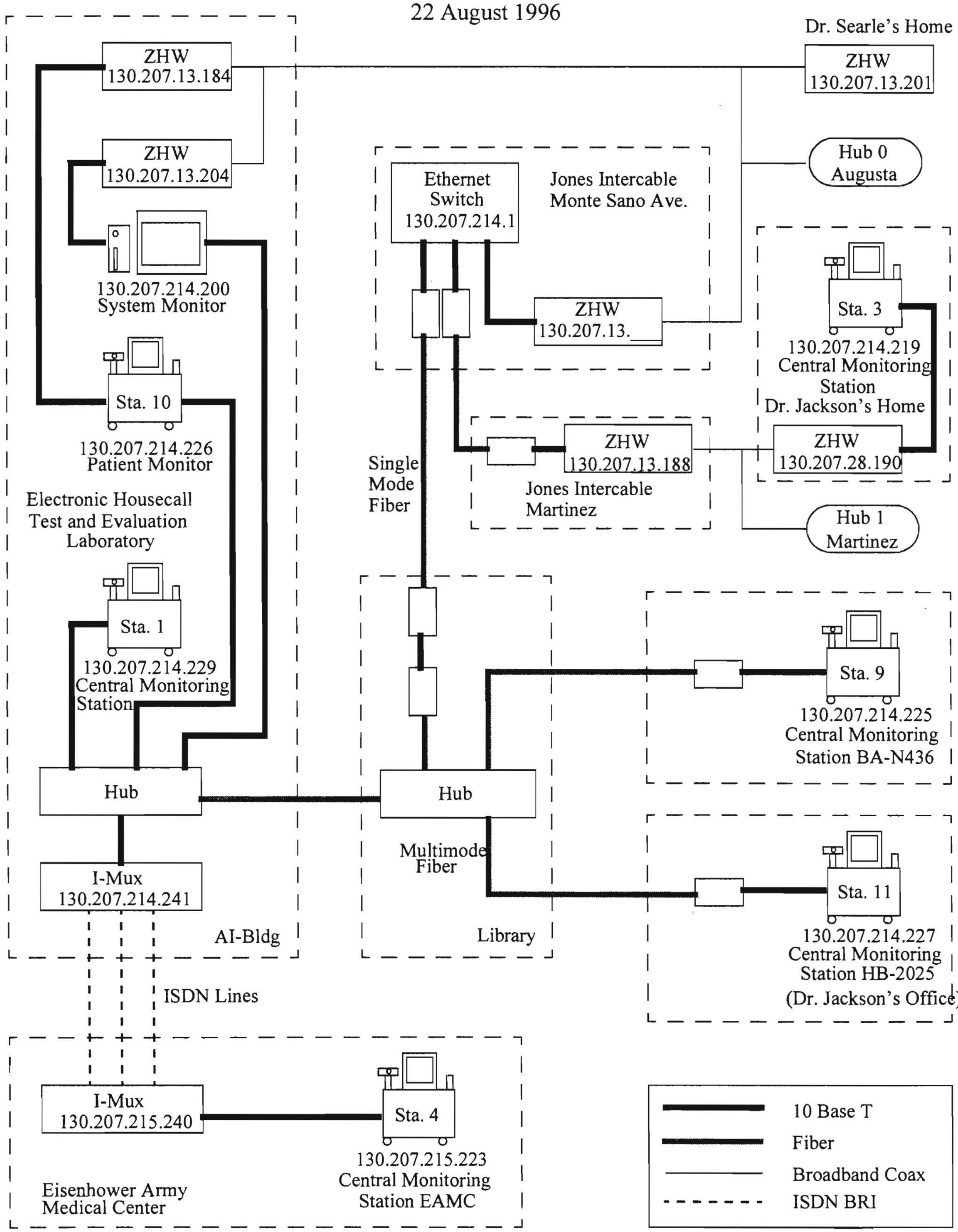
ELECTRONIC HOUSE CALL

NETWORK OVERVIEW



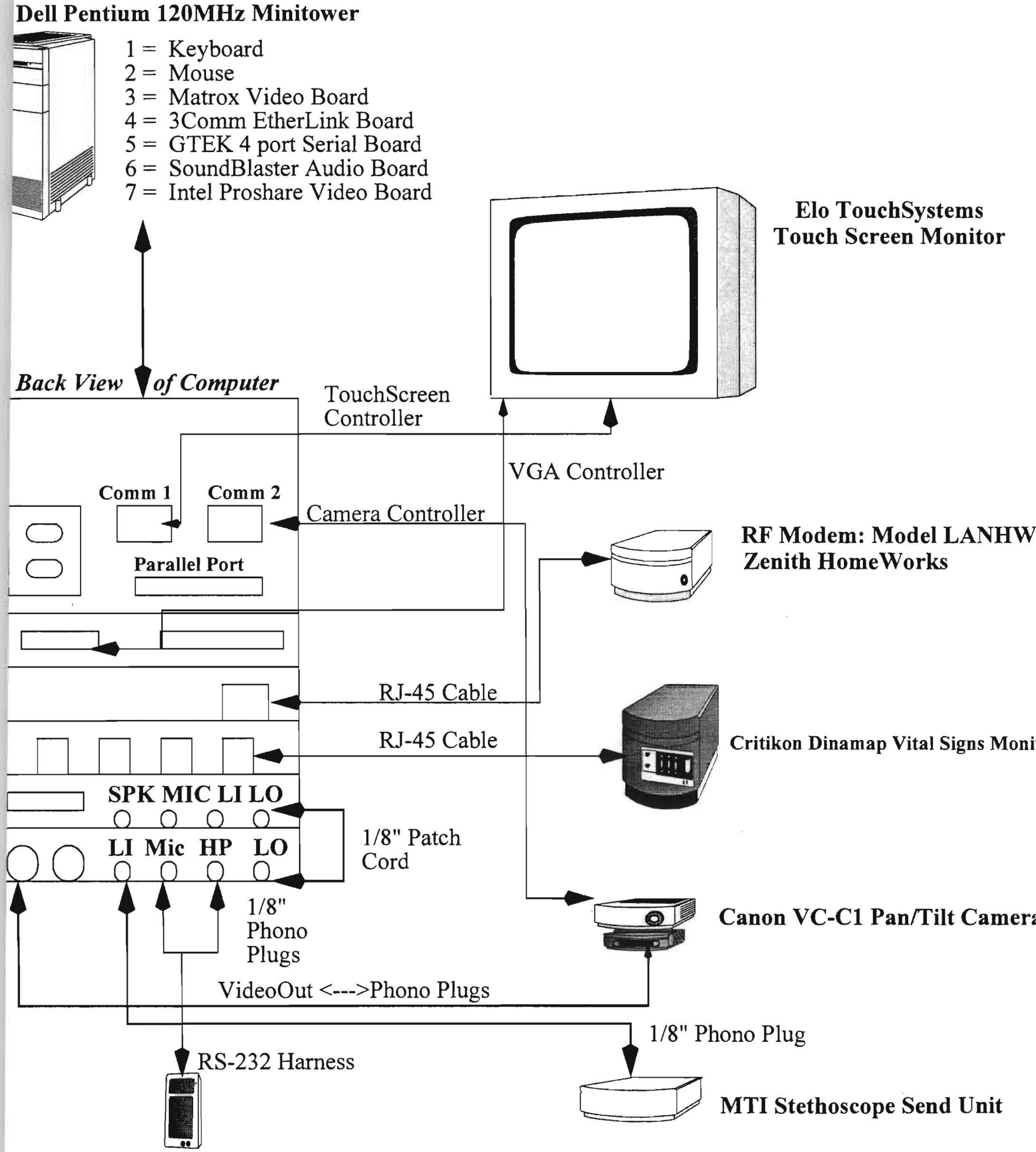
DETAILED NETWORK DIAGRAM

22 August 1996



Appendix D

ELECTRONIC HOUSE CALL HOME STATION



Appendix E

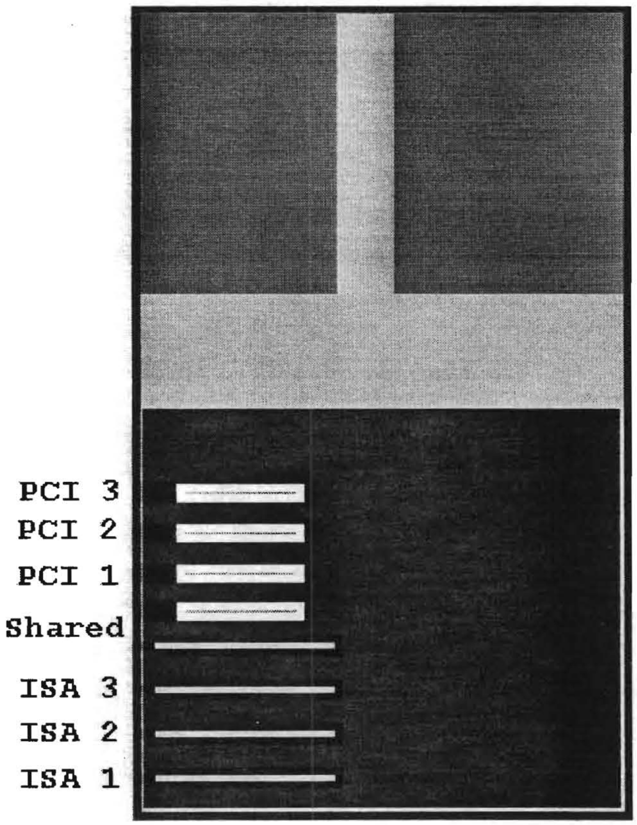
INSTALLATION OF ELECTRONIC HOUSE CALL

1. General :

- Record all parts on serial number checkout list.
- Save all extra parts and documentation in the box the Dell extras came in.

2. Install Boards:

- Remove the existing video board from the computer. Add extra RAM, if necessary, up to 32M total.



PCI 3 - Empty

PCI 2 - Matrox video board

PCI 1 - 3com Etherlink III board

Shared - GTEK serial port board (client/patient machines only)

ISA 3 - Sound Blaster 16 board

ISA 2 - Empty

ISA 1 - ProShare Audio/Video board

3. Set up GTEK board (client computer only):

- Port Addresses 100-120 - verify jumpers at JB6 to look like this: [] : []
- Shared IRQ 7 - Set the jumper group at the bottom of JB1 (OR gate output) to 7.
- Remove reset switch cable from motherboard (blue/balck twisted pair). Plug it into the first 2 points on JB2 (outside corner).
- Using red/black 15" cable supplied, connect other 2 pins of JB2 to the reset pins opn the motherboard (top front corner). Polarity does not matter.

4. Install Touchscreen Monitor :

- Connect the monitor to the display adapter (Matrox), connect the serial connector of the monitor (touchscreen cable) to COM1, connect AC power cord.

5. Install Windows 95 if not pre-installed:

• Boot up machine. Verify the computer is working correctly and the 'NUMBER9' error. From DOS prompt -

- Go to the windows directory, type SETUP and change the display adapter to VGA. Press Enter, Enter.
- Edit the Windows file C:\WINDOWS\WIN.INI and remove all references (the rest of the line) after the "load=" and "run=" lines in the "[windows]" section, so that there is a blank after each equal sign.
- If a client/patient machine, create GTEK directory under the C drive and copy WDOG.COM into it. Edit AUTOEXEC.BAT to include C:\GTEK\WDOG.COM 100.
- Edit AUTOEXEC.BAT. Remove the three lines near the bottom that contain the dell menu references.
  - rem [DellMenu], rem Ell\Dellmenu.exe, rem [end-DellMenu]
- Run Windows, and enter "BITC" for the name and "MCG/GTRC" as the company. There is no printer attached.
- Insert the Windows '95 disc into the CD-ROM drive. Run D:\WIN95\SETUP.EXE and install Windows '95.
  - Do not save old system files.
  - Choose custom system setup.
  - When the setup program asks you for a CD key, the number is on the back of the sleeve containing the Windows '95 Upgrade disc.
  - **Check** the Network Adapter Box..
  - Allow Windows to search for devices. A list of detected hardware should pop up. OK the component list. On the Network Components menu - add Microsoft TCP/IP as a network protocol. Choose '3COM Etherlink III BusMaster PCI'. Remove 'Client for Netware'.
  - Set the Mouse to standard types - Standard PS/2 Mouse. Set the Monitor to CTX - CTX 1765. Allow the default settings for the rest.
  - You do not need a startup disk. While it is finishing/rebooting, make sure it's hooked up to the net—ethernet connection in 3COM board.
  - The user name is 'EHC-0xx', with no spaces, numbered consecutively. Leave the password field blank.
  - Enable File Sharing in the Network control panel.

6. Network Setup

If, when you restart Windows, it gives you with a message that a DHCP server could not be located, then hit 'Yes'.

- Go to the Control Panel. (Start-Settings-Control Panel) Open Network.
- Enable NetBios communications - double clicking IPX/SPX and clicking the enable NetBios box and hit 'Ok'.
- Double click the TCP/IP protocol. Choose to specify IP address and enter 130.207.214.XXX where XXX is assinged to you. The sub mask will be 255.255.255.0.

Click the Gateway Tab and enter 130.207.214.1 and click 'Add', then 'Ok' (in parent window). Wait until later to restart Windows.

- In the network settings, click the Identification tab. Enter in for Computer Name - "EHC-xxx", for Workgroup - "HouseCall", and for description - patient's name.

7. Install Matrox driver from CD :

- Install Matrox CD-ROM. Choose "Install Win95 Drivers". Choose Control Panel-Display-Settings, and change desktop area resolution to 800x600 with color palette to 24 bit color. In the Screen Saver tab, set the screen saver to "none". Wait to restart Windows again.

8. Install Touch Screen adapter drivers:

- Start- Shut Down and restart in DOS mode option.
- Insert the ELO drivers diskette. From the "C:\" prompt, type "A:INSTALL" Installation is very easy; just hit enter for all defaults until the installation is complete. After installation has completed, type "GO" and calibrate the monitor.
- Insert the mouse disk and copy "MOUSE.EXE" to the C:\TOUCH directory.
- Edit C:\AUTOEXEC.BAT. Change the "SET MOUSE = C:\MOUSE" to "SET MOUSE = C:\TOUCH." (it's near the bottom.). Remove the next line "rem - By Windows Setup - C:\MOUSE\MOUSE.EXE /Q". Then, add the line "C:\TOUCH\MOUSE.EXE" in its place.
- Save file, remove floppy, and reboot the machine. Start-Settings-Control Panel and select Touchscreen. Calibrate the touchscreen again.

9. Install ProShare Video Software

- Goto Proshare directory on CD-ROM. Go into Disk1 folder. Double-click "Setup". Do a complete installation. Do not restart the computer after the installation is complete.
- Run/open 'C:\PSVIDEO\PSVIDEO.INI'. (the INI doesn't show on the desktop.) At the top of the file, insert the lines:
  [PERMISSIONMODE]
  STRICT=0
- Save this file, and open 'C:\PSVIDEO\PSUSER.INI'. At the top of this file, add the lines:
  [AVCS\PERMISSIONMODE]
  STRICT=0
- Save this file, and exit Notebook.
- RIGHT click on the Start button. Choose Open. Double click Programs, then StartUp. Delete ProShare Video - Listening. Get back to the desktop, and delete the Set Up Microsoft Network icon.

10. Install Visual Basic

- Insert the Visual Basic disc into the CD-rom. Double click My Computer, double click the Vb4 (D:) icon. Double click Setup.
- When Setup comes up, click 16 bit Visual Basic (the second button) for name, enter the computer name you entered earlier. (EHC-0xx) For Organization, enter MCG/GTRC.

- Do a complete install.
- Let it install into the default directory.
- Copy help files to your hard drive.
- Use the default group name
- Close setup window and eject CD.

11. Install Proshare Developer's Kit (PDK)

- Reboot Computer.
- Instert PDK CD. Open PDK folder, then 'Setup' (It's hiding to the right.)
  - 'Read license', close notepad and 'Accept'.
  - Don't install sample applications. It's quick and easy.

12. Install Quicktime

- Insert CLIO Awards CD. Open it, and click 'Install Quicktime'.
  - Follow the defaults. It's also quick and easy.

13. Configuration of the GTEK Comm Ports :

- Disable Printer : Start-Settings-Control Panel. Double click on 'System'. Click 'Device manager' tab. Click 'Ports'. Double click 'Printer port'. UNCHECK the 'Original configuration'. Click 'Ok'.
- Restart computer.
- Config ports : Start-Settings-Control Panel-Add New Hardware. Do not search for new hardware. Choose 'Ports'. Use defaults. Finish.
- Repeat last step 6 times or until Comm 8 shows on Device Mangaer. To check if correctly done - Control Panel-System. Click on 'Device manager'. Check the comm ports to see if 8 are listed.
- After the comm ports have been added to the 'device manager', the addresses and interrupts need to be changed.
  - Start-Settings-Control Panel. Double click on 'System'. Click 'Device manager'. Click 'Ports'. Double click 'Comm Port 5'. Click on 'Resources'. Double click 'Input/Output Range'. Set the lower value to 100. Double click 'Interrupt Request'. Set this value to 7. If a message comes stating that this number is already used, click 'OK'.
  - Repeat last step for all comm ports upto 8. The values for the comm ports are listed below.

Comm Ports	Input/Output Range	Interrupt Request
Communication Port 5	100	7
Communication Port 6	108	7
Communication Port 7	110	7
Communication Port 8	118	7

- Restart the computer.

- Remove Ports : Return to 'System' under Control Panel again. Click 'Device manager'. Click 'Ports'. Click on 'Comm Port 3'. Click 'Remove'. When asked if ok, click 'OK'. Repeat for Comm Port 4.

13.1. Install EHC Software :

- Put in EHC CD-ROM into drive.
- Open EHC folder. It should contain "home" and "hospital" software.
- Copy folders into a path - "C:\EHC\HOME" for Patient system or "C:\EHC\HOSPITAL" for Hospital system.
- Removing Read-Only Priviligies.
- After all the files are copied, go to the appropriate directory (either "HOME" or "HOSPITAL") and "Select All" files from the Edit menu. Go to File menu and then "Properties". UNCHECK the READ-ONLY privilege. Choose Apply and then OK.
- This needs to be done for every folder within either "HOME" or "HOSPITAL". This will ensure that all the files are NOT read-only.
- Restart the system for changes to take effect.

13.2. Setup for FTP :

- Make sure computer is setup for file and print sharing under Control Panel-Network.
- For PMS and CMS : After the EHC software has been installed, click on the 'InBox 'and choose under File-Sharing. Choose 'Shared As' and 'Full' with no password.
- On PMS : Right click on wood-grain bar at bottom - menu should appear. Put correct Hospital IP and under Hosp. Computer name - "EHC-xxx" of hospital unit.
- On CMS : Make sure patients are added to list and under network - add patient's unit # - "EHC-xxx".
- Copy the "LMHOSTS" file under the WINDOWS directory. If there is not one on the CD-ROM, then make a new one from NOTEPAD. The file only contains - "the IP Address", tab, and "the computer name" (example - EHC-0XX), carriage return - for all the systems on the network.
- Restart the computer.

14. Prepare and install the Dinamap :

- Automatic 'on' function: Remove outer casing. Under 'on' button, solder across the surface wires. Replace outer casing, check that it boots up automatically.
- Remove black mounting plate from rear base. Drill holes, screw onto surface using 1/4" spacers. Attach Dinamap to mount.
- Attach adaptor to Dinamap, plug cable into rightmost port of GTEK board.
- Affix diagnostic leads to tray with cable straps; leave space for stethoscope.

15. Initializing the Dinamap :

- Change SpO2 Power-on :
  - In the Main Menu, press the System soft key.
  - Press the Service key.
  - Enter the Service Code numbers: 2, 2, 1, 3.

- Press the SpO2 key. (Observe that the sensor's red/infrared indicators light; this is normal.)
- Press the Default key. (Each Default keypress toggles between standby and operate mode.)
- Power off the monitor; then power on again.
- Verify that the pulse oximetry power-on default is in the intended mode (operate or standby).

16. Stethoscope :

- **Patient/client machines :**
  - If necessary, open send unit case and trim gain potentiometer to appropriate output level.
  - Connect to Line In terminal of Proshare board.
  - Affix stethoscope along with Dinamap leads.
  - Headphones.
  - Install a (1/8" - male stereo cord) into the Line Out of ProShare and into the Line In of SoundBlaster.
- **Central Monitoring Stations:**
  - Connect the receive unit into the Line Out of ProShare.
  - Install the Andreis Tek stethphones into the receive unit.
  - Remove the high frequencies (1kHz and greater). This will remove the noise from the stethophones.

17. Peripherals :

- Open Call Port. Drill holes in base, screw base on far left side of cabinet top, angled slightly toward center. Reattach front; this requires small srewdriver ratchet.
- Open Altec speakers.
  1. Drill 1/4" hole in top of master speaker, at rear center of front half. Screw camera to speaker with 1/4-20 screw.
  2. Saw off part of bass port from rear half of master speaker to make room for screw head.
  3. Drill holes in base of rear half; screw onto cabinet top.
  4. Reassemble speaker.
  5. Repeat 3,4 for slave speaker.
- Cabinet door: Drill, tap (6-32) for hinges. Drill, countersink for closing screws. Attach to cabinet.
- Connections: See diagram.
  - AC power, keyboard, and mouse are obvious.
  - Touchscreen cable connects to COM1.
  - Camera control cable connects to COM2.
  - Add 1/8" stereo headphone jack patch cord between ProShare LO and sound board LI.
  - Monitor cable attaches to Matrox board.
  - Network cable (ethernet) connects to 3COM board.
  - Call Port connects to headphone and microphone jacks of ProShare board.

- Camera connects to leftmost jack of ProShare board, using ProShare cable.
- Altec master speaker connects to SPK of sound board.
- Patch cord for stethoscope in PMS only from LO of ProShare to LI of SoundBlaster.

• Patient sites:
- Dinamap connects to rightmost port on GTEK board.
- Stethoscope connects to LI of ProShare board.

Rear View of Dell Dimension XPS-P120C